



The economic organisation of building processes. On specialisation and coordination in interfirm relations

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Mikkel Andreas Thomassen

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Chapter 1 - Introduction to the emergence of research problems

1.1. Introduction

This thesis is an outcome of a PhD.-study initiated in relation to, and partly financed by, the programme called *Proces og produktudvikling i byggeriet* ("Process and Product Innovation in the Danish Building Industry" - referred to as the PPB-programme). The PPB-programme was an 8-years innovation programme launched in 1994 by the Danish Agency for Trade and Industry and the Danish Ministry of Cities and Housing aiming at improving innovation and productivity in the construction sector.¹

Undoubtedly, the programme has been a unique experience to persons from each of the 4 consortiums that have carried out development-projects as part of new build social housing projects. However, in a broader perspective the PPB-programme is not unique. In at least two ways it shares basic assumptions in much of the ongoing national and international debate on the construction sector (further discussed in section 1.4.). Firstly, it is generally believed that a wide range of problems troubles construction: low levels of innovation and learning, low level of trust and high level of conflicts, poor communication and coordination, fragmentation etc. all resulting in a poor performance of the sector. Secondly, within the last decade or so it has become more and more common to assume that problems and solutions have to do with the way the building process is organised and not so much with the technical issues (that appear to have been the main developmental focus of the sector in the majority of the post-war period).

To some degree, this thesis will concur with these two assumptions. It will apply an organisational perspective to the sector. And it will agree that its present performance is not necessarily the best possible.

¹ I will use the term "construction sector" rather than "construction industry" having in mind Ranko Bons (1991) observation that the term "construction sector" is more appropriate since construction is composed of several rather different industries. When the term "construction sector" is used during the thesis, it will generally not include civil engineering projects (physical infrastructure such as roads, bridges, ports etc) that often differ from house construction, in particular with respect to size and the number of trades involved.

But at the same time, the thesis will take one step back from the ongoing debate (including the PPB-programme). Rather than simply criticising the present organisation of the sector, this thesis will try first to understand it. As elaborated upon in section 1.4, we observe some identical organisational features in a wide range of countries. And we observe some of these features to be rather stable over time. If the present organisation is so inadequate, why did it emerge in so many different settings? And how did it survive?

It is the firm belief of this thesis, that it is hard to improve the sector if the benefits of present organisational forms are totally ignored. And that is why I will not rush to conclusions or recommendations until the very end of the thesis.

Yet, I do think improvements can be made. The main thread of the thesis is that the present organisation of the sector in many ways is a logical response to the ongoing and demanding market fluctuations. And hence, if we aim at truly changing construction, other ways of ensuring adjustability have to be envisioned, understood and established (probably in a simultaneous and thus very confusing process). But before dwelling upon the golden land, we may arrive at the very end of this thesis, I better get back to the introduction...

1.2. The personal starting point

Admittedly – and even though the work at hand deals with a range of problems central to economic theory and potentially is of relevance to many industries in general and the construction sector in particular – my interest in the construction sector originated in personal experience. As chairman for a social housing organisation, I had the pleasure of representing the client in a number of building projects. Some of these projects went wrong; most of them went terribly wrong. Projects were always delayed in the planning phase. The time schedule in the execution phase was only kept due to quick and not always fully satisfying solutions by the craftsmen at the building site. The struggle to meet budget restrictions seemed endless and were only solved in last minute cuts (changing the houses beyond recognition). And although some of us in the housing organisation personally began to enjoy the rough and seemingly random ride of construction, we were dragged more and more into the process of construction while all we wanted was

to provide rooms for students. We thought we bought a house, but what we actually bought was the right to pay for and participate in a play with new actors and, for sure, an open ending.

On top of things, the advisors (architects, engineers and the like) and contractors – no matter how trained and experienced they were – seemed unable to manage the process in a homogeneous and predictable way. This in spite of the fact that the process seemed remarkably constant over time; the involved parties did not appear to strive for new components or ways of building.

And yet, at the end of the day, some houses emerged from the chaos and struggle. Perhaps not ideal, perhaps not exactly on time, but they were there. Somehow a “mysterious force” made all the materials, planning and labour work together in some kind of system and a house was created.

Two questions were formed in my head and, to a large degree, they still echo through this thesis: First, what it is, that makes all the different and independently performed activities in a construction process act together in a more or less coherent way? And secondly, is it possible to eliminate, or at least reduce, the experienced problems by organising the process of construction in some other way and by this make the system more coherent?

Later at The Technical University of Denmark and at the Danish Building Research Institute, I discovered that the building projects in “my” social housing organisation were not particularly mismanaged. Rather the observed problems appear to be present in the construction sector in Denmark, USA, UK, Australia, Norway and Sweden and probably many other countries as well. And for the same reason, the (re)organisation of this sector has been on the political, industrial and (to some degree) academic agenda in these countries for approximately the last decade.

At the Copenhagen Business School I have been exposed to general economic concepts that have helped me to phrase the problems observed in construction in a more general way. In this context *coordination*, the *division of labour* and the *division of knowledge*, *interfirm coordination* *repetition*, and *coordination modes* are of essence.

The present dissertation is a result of these three interactive forces: (a) the ongoing debate on how to organise the sector, (b) the theoretical inputs (particular in the field of general economic theory) from three different academic environments and (c) personal experience. Even though I at times feared that this triangle turned out to be a Bermuda one, the impact of these three positions has been decisive as well as stimulating. Hence, the following introduction to the research problems (or *questions*) will have to include all of them.

I will start (section 1.3) by describing how an apparently rather limited research problem on “*how to coordinate*” along the way was expanded to include “*why to coordinate*” and “*by whom coordination should be done*”. I will then (section 1.4) consider how these three research problems draws on – and contributes to – the ongoing debate on the organisation of the construction sector. Section 1.5. considers the theoretical contributions and delimitations of the study. Hopefully, these two sections will reassure the reader, that the discussions raised are of general interest and not only serve to satisfy personal curiosity. Having clarified these different perspectives, the three research problems are revisited and summarised in section 1.6. The chapter concludes by providing the reader with an outline of the thesis (section 1.7).

1.3. Encircling the research problems of the thesis

1.3.1. How to coordinate

So the original “mystery” (to me at least) that fuelled my interest to engage in a PhD.-study was to understand *how the independent actors and activities of the building process come to act together in a coherent way*. Soon, this brought me to the concept of *coordination* which can be defined as how “*to make different parts function together efficiently*” (Oxford Advanced Learner’s dictionary, 1994).

Thus, in the outset my research problem was “simply” about *how* coordination of building processes is and should be done.

Digging into the literature on coordination (discussed further particularly in chapter tree), I learned there are different ways (or “modes”) by which dispersed interests and information can come into agreement. Coase (1937) furthermore made it clear that there is not one best way to coordinate since the capacity of these different modes has to be determined in a comparative and empirical assessment.

Gradually, the question of how to coordinate turned out to include two sub-questions. Firstly, how does a typology of coordination modes look like. Secondly, when a typology on different information handling principles has been identified, what can we say about the comparative advantages of each mode. Consequently, one research problem of this thesis can be formulated as follows:

What particular coordination modes are used for construction and how do they cope with the activities involved in construction?

1.3.2. Why do we need to coordinate?

But the question of *how* to coordinate spurred a number of additional and closely interrelated questions.

One question relates to *why* we need to coordinate. One might wonder if we could benefit from organising in a way in which coordination is not needed at all!

The starting point for this reflection is undoubtedly the *Wealth of Nations* by Adam Smith from 1776 (1970). When Adam Smith identified the *division of labour* as the main source to the wealth of nations, he also located the flipside of this division: the need for *exchange* – or *coordination* as it will be termed here – linking together the specialised units ((1776) 1970, p. 119). Without “*the assistance and co-operation of many thousands*” not even the most simple products could be produced and made affordable to common man (ibid, p. 117).

Hence, in order to understand the extent and specific nature of a coordination problem, the way in which tasks have been grouped together in activities carried out by different persons (i.e. the division of labour) and different firms (i.e. specialisation), has to be considered. And conversely, the division of labour and specialisation cannot be understood without considering the level of coordination costs by which they are limited:

“An analysis of the forces determining the division of labor provides crucial insights not only into the growth of nations, but also into the organization of product and labor markets, industries, and firms.”
(Becker and Murphy 1992, p.p. 1157-58).

Hayek (1937) expanded on the idea of Smith by clarifying that alongside the division of labour goes *the division of knowledge*. This raises the

questions of “...how the spontaneous interaction of a number of people, each possessing only bits of knowledge, brings about a state of affairs in which prices correspond to costs, etc” (ibid. p. 49).²

Thus, it is hardly possible to discuss the concept of *coordination* in any meaningful way without discussing the concepts of *division of labour* and *specialisation*. And consequently, a second research question of this thesis is:

How is the division of labour in construction and what are the consequences hereof with respect to coordination?

1.3.3. Who coordinates?

A second addition to my original “how-question” on coordination relates to the organisation of coordination - by *whom* coordination is done. In order to understand how this question emerged, once again we have to include some of the theoretical insights discussed more thoroughly in chapter 2 and 3.

From Smith (1970) we learn that the benefits from dividing labour relate to repetition of activities, and that disruption in production consequently limits the division of labour. However, since changes limit the benefits from dividing labour, it seems obvious, that people would organise in ways by which propagation of changes are avoided or, at least, minimised. As argued in chapter 2, the *firm* - in which *specialists in coordination* buffer external changes and *specialists in production* perform repeated activities under nearly stable conditions - represents an organisational response to changes.³ In this perspective, the strength of the firm is, that it, by repeating sequences of activities, allows people to work with (almost) identical activities or with coordination of (almost) identical sequences of activities (and thus allows a division of labour).

Hence, in order to understand the issue of coordination, the boundary question (“what determines the boundaries of the firm”) is of interest:

² Richardson addresses the same fundamental question in another classic work *Information and Investment* (1960): “...The general problem...(is) how, in a competitive economy, a rational allocation of resources can result from the investment decisions of many independent entrepreneurs”.

³ As also pointed out in chapter 2, even though the firm understood as a set of repeated resources and activities cannot be assumed *per se* to be identical to the contractual and legal definitions of the firm, due to information costs, it is likely that these different boundaries overlap significantly.

are activities coordinated within a single firm, bilaterally between firms or by some sort of intermediate third party? Or put differently, “it makes sense to start from an analysis of the effectiveness and efficiency of the boundaries of organizational units before examining”, for instance, “the coordination mechanisms.” (Grandori 2000 chapter 11, p. 3).

In short, the way activities are coordinated cannot be separated from the way they are organised.

For instance, it is often claimed that the fragmented nature of construction – many companies and persons that do not know each other beforehand are involved – trouble coordination (Turin 1967, Eccles 1981, Slaughter 1993, Pries and Janszen 1995, Kommissionen 1997, Costantino *et al* 2001, BUR 2001). If so, we will have to understand how integration of activities within the firm can enable coordination. And what the limitations of coordination within firms might be. Among other things, this will allow us to ask – what in light of the often proposed disadvantages of “fragmentation” appears to an obvious question – “why not coordinate all activities within a single firm?”.

The third research problem can be formulated as follows:

What are the roles of construction firms with respect to coordination: do coordination takes place within or between firms and what limits that activities are handled within a single firm?

In order to understand the coordinating role of (construction) firms, we will have not only to consider the advantages from firms, but also their disadvantages. As it will argued in chapter 2, a limit of the firm bridging many subsequent activities is that continuing association of activities implies commitment to particular firms and individuals producing particular products. This in turn induces lack of adaptability to external changes like say quantitative or qualitative changes in demand of final customers.

Hence, sources to change (or put differently *lack of repetition*) have to be considered. Not only as it according to Hayek (1937) is change that (in combination with no perfect foresight and the division of knowledge) creates the need for coordination. But also because change affects the possibilities of enabling coordination by repeating sequences of activities within a firm. As it will be shown empirically in chapter 5, a key

characteristic of the construction sector is the dramatic change in overall demand. And as it will be proposed throughout the thesis, the way these macro changes propagate into the meso- and micro-levels is a key to understand the present organisation of (various aspects of) the construction sector.

The proposed separation of the “*how to coordinate*” and “*by whom coordination is done*” may need an additional remark before this introduction proceed. Traditionally, these two questions have been considered so tightly related that no distinction has been made. In Coase’s seminal contribution (1937) on coordination, the market was defined by using one coordination mode (price coordination), the firm another (the absence of price coordination). Only recently it has been pointed out, that market principles can penetrate firms and firm principles can penetrate markets (Imai and Itami 1996). This consequently implies that it cannot be taken for granted, that the boundaries of the firm and the boundaries of a coordination mode coincide in a clear and unambiguous way.

In order to encompass this insight in the present work, I will discuss *the organisation of coordination* and *the coordination modes* as two separate matters throughout the thesis. With the organisation of coordination I mean whether coordination is done within or between firms, and in case of the latter, if it is done directly between firms or by a third party of some sort. With respect to coordination modes, I refer to the different principles by which information is structured (for instance, is communication taking place directly between the persons, whose actions have to be coordinated, or is information mediated by, say, a superior).⁴

The theoretical part of the dissertation is structured according to this distinction. Chapter 2 discusses the organisation of coordination whereas the execution of coordination by different coordination modes is investigated in chapter 3.

⁴ As a final remark to the question on *how* versus *by whom* coordination is done, it should be noticed, that even though these questions are not identical, they are nevertheless interlinked: as seen in the empirical part, the way coordination is organised, has a significant impact on the information involved in coordination and hence influences the selection, as well as the particular “shape” of coordination modes.

1.4. Empirical contributions and limitations

1.4.1. The ongoing debate on how to organise the construction sector

The idea that construction is more than a technical discipline is not new. For instance, in 1966 the Tavistock Institute (p. 14) recognised the importance of what they termed the “administrative field” of construction and similarly in 1975 Turin (p. IX) finds that “..everybody in the industry (and some people outside it) knows that management is perhaps the scarcest of all resources in the building process...”. Stinchcombe 1959, Bowley, M. 1966, Kreiner 1976, Eccles 1981 and 1981b are other examples. However, it is within the last decade or so that organisational and economic (and not merely technical) issues of construction have gained momentum outside a small group of people working with and in the construction sector.

A very clear manifestation of this “new approach” to construction is the report written by Latham in 1994: *Constructing the Team*. In this review of procurement and contractual arrangements in the UK construction sector, Latham notes with respect to the problems observed: “Above all, it needs teamwork” (Latham 1994, p. V). This goes for the relation between clients, contractors and design consultants, as well as on the building site, and includes arrangements such as partnering (ibid., p.p. 61-62). The Latham Report represents a strand of literature that argues in favour of moving from arm length transactions to close collaboration - often based on trust - between two or more partners.

In the 1990's this idea was primarily coined in the concept of *partnering* arrangements (Thomassen 1999b, Thomassen and Hansen 2001).⁵ Gradually, the focus has gradually changed somewhat from partnering to the concept of *supply chain management* stressing the need to

⁵ A commonly used definition of partnering (see for example Matthews 1996, p. 119; Barlow et al 1997, p. 6; Conlye 1999) proposed by CII in 1991:

"...[Partnering is] a long-term commitment between two or more organisations for the purpose of achieving specific business objectives by maximising the effectiveness of each participant's resources. This requires changing traditional relationships to a shared culture without regard to organisational boundaries. The relationship is based upon trust, dedication to common goals, and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost-effectiveness, increased opportunity for innovation, and the continuous improvement of quality products and services."

incorporate most or all parts of the value chain (F.R.I. 1993, Flanagan 1998, ATV 1999, Thomassen 1999, Kumaraswamy and Dulaimy 2001).⁶

Irrespectively of the name, this orientation towards in-depth (and in some case long term) relations between construction firms has been a source of a wide range of intertwined research and building projects putting the ideas to the test.

These projects have been on the agenda in a number of countries.

U.S. was a first mover with respect to partnering (Conlye 1999). UK was soon to follow with the Latham-report from 1994. In 1998 the Construction Industry Task Force published “rethinking construction” (also coined the “Egan-report” due to the Chairman John Egan). Both reports examined the problems of the construction sector and stressed the need for partnering. At the same time a number of the major clients, such as Sainsbury and British Airways Authorities, have organised building projects in accordance with the partnering idea (Bennet 1998). In a follow up report in 2002 – “Accelerating change” – Egan now stresses that “Integrated team work is key” (Strategic Forum for Construction 2002, p. 7): “It is self evident that a construction team that only constructs one job learn on the job at the client’s expense and hence will never be as efficient, safe, productive or profitable as those that work repeatedly on similar projects” (ibid). Accordingly, a key strategic target set out in the report is that by the end of 2004, 20% of construction projects by value should be undertaken by integrated teams and supply chains. By the end of 2007, this figure should rise to 50%. Rethinking construction also paved the way for initiatives like the “Construction Best Practice Programme” and “Movement for Innovation” (M4I).

In *Australia* partnering has been a part of the Australian Government reform strategy for the Building and Construction sector since 1991 resulting in a number of partnering based building projects (Uher 1999).

In *Sweden* new ways of collaboration has been tested in for instance *Svedelamodellen* where the long term and cross-functional collaboration between the client and the design- and build contractor aimed at lowering production costs for multi-unit apartment buildings (Persson

⁶ Cooper *et al* (1997) defines supply chain management “the integration of all business processes across the value chain.

1999). In 2003 “Byggerådet” – an association supporting collaboration between the construction sector and universities in the south of Sweden – has launched “Byggprocessforum”, that has appointed “information and coordination” and “work site organisation” as some of the key areas during their first year of operation (Birve and Hansson 2003).

In Norway a three year programme, “Samspillet i Byggeprocessen” (SIB) was launched in 1996 aiming at improving productivity in construction. A central element in this programme was to enhance integration between planning, production and supply of materials (referred to as partnering) (Eikeland 1998)

Denmark is no exception. In 1994 the aforementioned PPB-programme was launched. Soon after, refurbishment was also made subject to new ways of cooperation (especially at the site-level). This happened in *Project Renovering* (“The Urban Renewal Project”); a governmental programme initiated in 1995 and concluded 1999. *Projekt Nye Samarbejdsformer* (“Project new forms of Collaboration”) initiated by the Danish Ministry of Cities and Housing and running from 1998-2001 sharpened the focus on collaboration (in particular *partnering*) even further. These programmes are (intended to be) carried on in a third governmental programme, *Projekt Hus* (a ten years programme commenced in 1999). Lately, a new building policy for the government has emerged, among other emphasising the use of partnering and benchmarking (Erhvervs- og Boligstyrelsen 2003). The foundation *RealDania* has devoted part of their financial resources to productivity-improvement of the building industry by means of new organisational forms. For instance, they have supported the establishment of *The Benchmark Centre for the Danish Construction Sector* that has appointed management of the building process as one of their 3 major themes.⁷

⁷ A large number of publications has accompanied this movement in Denmark, for instance: *Dobbelt Op* (F.R.I. 1989), *Synergier og barrierer i byggeriet – på sporet af den tabte produktivitet* (F.R.I. 1993), *Byggeriet I det 21. århundrede – Industriel reorganisering af byggeprocessen* (ATV 1999), *Byggeriets Fremtid – fra tradition til innovation* (Byggepolitisk Task Force 2000), *Byggeriet – på vej ud af den fastlåste situation. Og hvad så?* (BUR 2001), *Byggeriet i Vidensamfundet* (Erhvervs- og Boligstyrelsen 2002), *Staten som bygherre - vækst og effektivisering i byggeriet* (Erhvervs- og Boligstyrelsen 2003).

1.4.2. Some characteristics of construction

In the ongoing debate on how to improve construction, the similarities appear more striking than the disparities. The similarities of the prescribed remedies seem to suggest that construction share a range of organisational features in a wide range of countries. And in fact, the international literature on the organisation of construction seems to suggest some fundamental characteristics of construction.

While some differences between countries do exist (see for instance Winch 1994 for a comparison of the French and British procurement system, or Miozzo and Dewick's 2001 for a comparison of the Germanic models of corporate governance versus a more market-oriented Anglo Saxon model for innovation), and even if data on construction are poor and erratic and hardly comparable across nations (Ruddock 2002); it may be justified to state, that building processes in most European and Western countries "look much alike" (Pries and Janszen 1995).

Besides the overall characteristic of being organised in temporary project organisations (Turin 1967, Winch 1994, ATV 1999, Dubois and Gadde 2002), other common organisational traits are believed to be:

- a trade-based organisation of companies and individuals (Stinchcombe 1959, F.R.I. 1993, ATV 1999);
- labour intensive (or put differently, small amount of fixed capital per worker) (Sudgen 1975, Groák 1992, González-Díaz *et al* 2000);
- fragmentation due to many small (and often subcontracting) firms (Turin 1967, Eccles 1981, Slaughter 1993, Pries and Janszen 1995, Kommissionen 1997, Costantino *et al* 2001, BUR 2001);
- the separation of design and coordination from production (Bowley 1966, Nam and Tatum 1988, Groák 1994, Flanagan *et al* 1998, Miozzo and Ivory 2000, González-Díaz *et al* 2000);
- highly interdependent activities (Tavistock Institute 1966, Bishop 1975, Robertson 1975, Dubois and Gadde 2002);
- poor communication and coordination (Tavistock Institute 1966, Turin 1967, Kommissionen 1997, Shammass-Toma *et al* 1998, Carlsson and Josephson 2001, Davey *et al* 2001);
- "conservatism", little change and a low level of learning and innovation and in turn low improvement in productivity (Russel

1981, Nam and Tatum 1988, Connaughton *et al* 1995, Pries and Janszen 1995, Kommissionen 1997, Flanagan 1998, Kumaraswamy and Dulaimy 2001, Cripps 2002, Dubois and Gadde 2002, Erhvervs- og Boligstyrelsen 2002, Fairclough 2002);

- competition only on price reduction, not on innovativeness or optimisation of client values (Flanagan 1998, Miozzo and Ivory 2000, Miozzo and Dewick 2001, Kumaraswamy and Dulaimy 2001,);
- low levels of trust and high levels of conflicts (Korzynski 1994, Flanagan 1998, Loosemore 1998, Loosemore 1999, Miozzo and Ivory 2000); and
- a sector troubled by low quality, late delivery and overspending (Kommissionen 1997, Flanagan 1998, ATV 1999, Miozzo and Ivory 2000, Skamris 2000, Byggeskadefonden 2001, Erhvervs- og Boligstyrelsen 2002).

Furthermore, it has also been suggested that the problems of construction are remarkably stable. Flanagan (1998, p. 13) takes this point of view to the extreme when he in his short review of 800 years of building history in UK observe that it is striking "...how little the problems have changed over the years, and how regularly the same ones crop up".

The suggestion that characteristics (and perceived "problems") of construction show similarities across time and across national settings guides the search for explanations of (and solutions to) present organisational forms in a particular direction. It seems that we should not be too concerned with explanations that are tightly related with time-specific idiosyncrasies of a national or regional setting. Of course such issues matters, but there have to be more general forces in play at the same time.

1.4.3. The empirical contribution of the present work

The three research questions on "why, by whom and how" to coordinate addresses in multiple ways the above-mentioned debate and add insights and explanations to the characteristics.

The question on "why we need to coordinate" will bring us to the reasons to why a trade-based division of labour arises and why - even

though it might appear “conservative” – it is maintained. It also informs us of reasons to the particular patterns of learning and education found within the sector.

The question on by whom coordination is done will provide reflections on why long strings of subsequent activities rarely are coordinated within the same firm. And why firms often remain of a limited size. Hence, the “whom”-question relates to the issues of fragmentation including the separation of production and design. And it establishes a frame for analysing the possibilities for (and limitations of) engaging in more integrated supply chains.

Reasons to poor communication and coordination are directly touched upon in the question on how to coordinate. This question includes an analysis of the benefits and disadvantages of moving towards a more team-based coordination mode – not only in the design phase but also at the building site. The issue of teaming is interesting with respect to partnering, as much of the partnering literature favours that participants of a project should be allowed to communicate freely and directly without regarding organisational, professional or hierarchical boundaries (in other words, they argue in favour of coordination by teaming). The thesis also raises (critical) perspectives to the use of partnering in the sense that it gives reasons to low levels of trust and high levels of conflicts in construction (reasons that are not always explicitly reflected upon in the partnering literature).

Indirectly, the research questions also bring perspectives to why we observe a particular kind of innovation in construction. Or put differently, why the sector appears to be so conservative. Similarly it will shed light on issues relating to low quality, late delivery and overspending.

As mentioned in the beginning of the introduction, much of the ongoing debate (as shortly reviewed in the above) implicitly assumes that the present organisation of the construction sector is inefficient. However, at the same time we observe some identical organisational features in a wide range of countries. But if the present organisation is inefficient, why has it emerged and survived in so many different settings? Why did we not observe that other ways of organising the industry - deliberately or by chance - were introduced a long time ago?

To illustrate this perspective: The construction of the Empire State Building in New York in 1930-31 was organised with significant partnering elements: there was a close interaction among (a) the parties in the planning process (i.e. clients, civil engineers, architects, and general contractors); (b) between the planning team and the subcontractors; and (c) between the producers of building materials and the planning team (especially prefabricated iron bars innovated especially for the erection of the Empire State). The Empire State was a remarkable project not only with respect to the final product, but also concerning the process that involved numerous product-innovations as well as a record building time (yet to be beaten?) of just eleven months for a building with 86 floors (Willis 1998)! And yet, U.S. Army Corps of Engineers could introduce partnering as a new principle in 1989 (Conley 1999).

Perhaps the major contribution of the present work is that it tries to explain the *raison d'être* of the present organisation of construction rather than simply describing or criticizing it. As it will be argued, existing organisational forms in many ways minimise on the total costs related to production and coordination. Or to concur with Turin (1967, p.p. xi-xii):

"...one must conclude that the building industry is indeed a very healthy and sophisticated machine, responding as it does to a challenge put to it in terms that would be unacceptable to so many other more reputable industries."

This does not necessarily imply that there is no room for improvement of the sector. But we have to engage in the "difficult task of understanding how the process actually works, what are the forces acting upon its participants and influencing their decisions and their relationships, in order to decide on the most suitable course of action to improve the situation." (ibid, p. xii).

To study the present organisation and performance of the construction sector is of course not a novel idea. Besides in many governmental reports and the like, this is witnessed in the "classical" works of Stinchcombe 1959, Tavistock 1966, Bowley 1966, Turin 1967 and 1975, Kreiner 1976, Eccles 1981 and 1981b as well as in an increasing number of recent contributions that within Scandinavia alone will feature works like Clausen 2002, Bang 2002, Dubois and Gadde 2002.

This thesis differs from the majority of these contributions in at least two ways.

First of all, it takes a specific theoretical departure, “organisational economics”, as explained below (section 1.5). Perhaps because organisational economics in general is not developed directly in relation to the construction sector, it seems to me that it enables an explanation to fundamental organisational features like the division of labour, the role of the firm etc. Theories “born and raised” within construction might face the danger of being so used to these characteristics that they are taken for granted or described more than explained.

The second way this thesis positions it self relates to what is considered the independent variable(s), i.e. the variable(s) that explain other variables.

Construction is believed to have many (particular) characteristics as discussed previously (section 1.4.2). An important question in order to understand – and ultimately improve – the sector is if any of these characteristics are more fundamental than others. Put differently, if a hierarchy in these characteristics could be identified, we will know the causes from the effects and consequently we will know where to target our improving efforts.

To sort the fundamental variables from the derived ones is not an easy exercise as they interacts in various ways. An ideal way to go about this problem would be by means of for instance experiments in which one variable is changed at the time in order to excess it impacts. However, as discussed in chapter 4 on method such controlled experiments have not been found to be a feasible research strategy for this Ph.D.-study. As it will be seen on the many pages that follow, this makes the discussion subtler.

One possibility is to claim “everything interacts”. For instance, Groák (1992, p. 41) finds that it is the *combination* of industrial uncertainty, market uncertainty, project uncertainty, workplace uncertainty and uncertainty of the site organisation that “distinguish building from most other industrial and service activities”.

This thesis will try to be a bit more specific as it will try to substantiate the argument that present organisational forms to a large degree are a response to the need for flexibility created by *changes in overall demand*.

The cyclical nature of construction is often pointed out as a central characteristic of the sector (Arctander 1955, Bishop 1975, Hillebrandt 1975 and Hillebrandt *et al* 1995, Kommissionen 1997, V. Smith 1999, Miozzo and Ivory 2000, Bang 2002). In continuation of this insight, it will be argued throughout the thesis that changes in overall demand - that in turn partly can be explained by the durability and expensiveness of buildings - affects the way firms, projects and individuals are organised. Thus, the thesis is an attempt to see how much of the present organisation that can actually be explained as a response to a single (independent) variable found at the macro-level.

In the terminology of Groák this implies that I will explain project uncertainty, workplace uncertainty and uncertainty of the site organisations as responses to market uncertainty and not the other way around (market uncertainty are then again partly created by industrial uncertainty). Subsequently, I will not agree with Groák (1992, p. 44) that all of the five levels of uncertainty necessarily are “characteristics, not problems to be solved”.

Other “characteristics of a building as a product which make it different from all other products” (Turin 1966, p. 9) than the above mentioned (this section and section 1.4.2.) have been suggested more or less explicitly as independent variables:

- *Heavy and bulky materials* which in turn creates *local markets and limited import and export*. Difficulties in transportation can also explain the fragmentation of the sector (Arctander 1955, Turin 1966).
- Production is influenced by *weather conditions* and is *highly seasonal* (Kommissionen 1997, Bang 2002).
- *Restrictions on working practices and final outputs* (Bang 2002), partly in order to ensure the safety of workers and coming inhabitants.
- *Made to order and customised products*, partly due to site constraints and individual specifications of clients (Arctander 1955, Bang 2002).

I will not deny the impact of these variables. Each of them probably deserves a Ph.D.-study in their own right. However, a brief reflection suggests that not all of them are equally well suited for explaining why the organisation of construction in some respects supposedly are (a)

identical over time and in different parts of the world and (b) different from other sectors.

With respect to heaviness and bulkiness and associated transport problems, there has been an ongoing change in the costs and speed of transportation. As early as 1946 it was observed that:

“Even at 300 cubic feet we can get eight packaged houses into a freight car and we can ship by rail to the seaboard – the farthestmost point in the United States from Wichita – for \$75 a house. We can ship economically to any place in the world, because when we get to seaboard the ocean rates are so cheap we can ship to any place in the world for a few hundred dollars total from Wichita” (Fuller 1946, quoted from Russel 1981, p. 707)

If transportation is a decisive variable with respect to the organisation of construction, we would other things being equal expect to find that construction change as the facilities of transportation changes over time. It should also be expected that construction differ in accordance with the transport facilities of different regions. This is, to the best of my knowledge, not the case.

Similarly if weather and seasonal impacts are crucial we would expect to find large regional variations. It would for instance be interesting to test the hypothesis that the productivity of construction is positively correlated with some measurement for the hospitality of the climate. Besides, other things being equal, we should also expect to find similarities with other sectors troubled by the weather and seasonal changes, for instance agriculture. Productivity measures do not – as seen in chapter 5 – support this hypothesis.

Construction is indeed regulated with respect to working procedures and specifications of the finalised products. But is this any different from production of, say, cars, ships, or planes?

Finally, there are variations caused by different sites and clients. This study will not claim that these variations do not exist. But at the other hand, it is first of all questionable if housing needs etc. are different to a degree that each project has to be unique. Secondly, other sectors are believed to be able to customize production with an organisational set-up different from that of construction (ATV 1999).

Trying to explain a vast area like the organisation of construction largely by change in overall demand as the independent variable is of course a simplification. Yet, with the words of Coase (1937) we should keep in mind that an explanation should not only correspond to the real world, it should also be “tractable”.

Contributions to (and from) other sectors

So far the empirical contribution has been discussed with respect to the construction sector. And the particularities of the sector has been emphasised.

However, it may be claimed that the conditions found in construction apply to an increasingly expanding field of economic activities (Groák 1994, Gann and Salter 1998). Or perhaps even that construction is “a model for the future development of mass production” (Winch 1994). If so, construction can lend insights to, and gain insights from, a range of current discussions.

For instance, construction potentially contributes to the wider issue of *project organisations* and issues related to *inter-firm cooperation*. Construction activities are, and have been for a long time, generally not controlled within firms or not only structured by price-mechanisms, but are handled by close interactions across the boundaries of firms. Thus, construction is well suited for the study of inter-firm relations (Korczynski 1994), and rather than treating “special characteristics in construction as problems, because they are anomalous when compared with the idea of a single industry based on the manufacturing model...we now see that construction offers paradigms of response to ...uncertainty” (Groák 1994, p. 291). More precisely, as noticed by Stinchcombe (1985), construction shares organisational features with other forms of one-off production, such as offshore oil production, weapons research and development, software development and the computer manufacturing industry, and some sales organisations. This point of view is presently being developed by the work on Complex Product Systems, where the complexity of a system is believed to have a major impact on the way it is innovated and coordinated (Gann and Salter 1998, Hobday 1998, Hobday 2000).⁸

⁸ A wide range of product dimensions - such as the scale of the product, technological novelty,

Construction can perhaps also inform us on the organisation of sectors in which firm-based authority supposedly plays a limited role. Even though one should be careful to proclaim “the end of bureaucracy”, as Bennis did as early as 1964 (J. Pfeffer 1978, p. 130), for sure, the traditional authority based firm is believed to face complications (N. Foss 2000a). Perhaps this has to do with the present preoccupation with *innovation and learning* as main drivers of competitiveness and wealth of nations. If innovation and the ability to learn are of essence, it is not only difficult, but also unsuitable to put up defined goals when entering a process of innovation, where goals by definition are unknown. At the same time it is as difficult for managers to monitor or routinize activities, which do not follow a recurring and well-known pattern, as it is to absorb the new knowledge being created.

So in general, even though construction may seem mature (some might say “old-fashioned and conservative”) with respect to the technology used, the way it is organised and, as part of this, the way it is coordinated, presumably relates to issues and problems of current interest for economic activities far beyond the construction sector. Thus, in an organisational sense, the construction sector appears to be highly “modern”.

1.4.4. Empirical limitations

This Ph.D.-study will be based partly on general statistical, partly (and primarily) on a single case study on coordination practices in a new build social housing project. Reasons to - and limitations of - this

intensity of user involvement - constitute the complexity of a system and consequently there are many potential Complex Product Systems candidates. Hobday (1998, p. 697) mentions more than 80 candidates, for instance large construction projects, development of software systems, military systems, plants etc. Interestingly, “some high cost, mature products would not be included (e.g. roadworks and *simple building constructs*), as they involve a narrow range of knowledge and skills and utilise mostly standard components and materials.” (Ibid., p. 692, italics added). Whether “building constructs” are more or less complex than, for instance, the candidates mentioned by Hobday can of course only be decided by empirical investigations. However, at first glance, it seems to me, that even rather “simple” projects as the multiunit residential house case investigated in this Ph.D. (see chapter 6) would score high on some of the complexity variables outlined by Hobday (ibid., p. 691), for instance on “degree of customisation of final system”, “feedback loops from later to earlier stages”, “intensity of user involvement”, “uncertainty/change in user requirements” and “intensity of regulatory involvement”.

approach are discussed in the chapter on method. As argued with respect to the external validity of the case study, what I aim for is “analytical generalisation” and not “statistical generalisation” (Yin 1989).

1.5. *Theoretical contributions and delimitations*

This study intends to provide insights to the theoretical field *organisational economics*, i.e. a comparative assessment of the cost of producing and allocating resources by different structures of ownership and coordination. More specifically, the study aims at bringing empirical insights to *theories on coordination* addressing questions of *why* we coordinate, *how* we coordinate, and by *whom* coordination is done.

“Organisational economics” has been chosen as the theoretical point of departure for several reasons. The first reason is that organisational economics directly and rather thoroughly addresses all three research problems. Besides, by treating the questions of how to organise and coordinate construction as fundamental and general problems on how to organise economic interactions, I hope to have gained two advantages. Firstly, the work becomes of interest to a wider range of scholars than the ones particularly interested in construction. Secondly, by stressing the general character of the questions asked, it has been easier to get in dialogue with existing bodies of theories within organisational economics, rather than engaging in a perhaps unnecessary exercise of establishing an theoretical framework solely suited for construction.

As briefly sketched out, fundamental theoretical contributions to the research problems on coordination can be traced back to Adam Smiths *Wealth of Nations* from 1776 and *The nature of the firm* and *Economics and Knowledge* published in 1937 by Coase and Hayek, respectively.

So the basic foundation for addressing the questions of *why* we coordinate, *how* do we coordinate, and by *whom* coordination is done was laid down more than 60 years ago. Taking this into account, it is somewhat surprising that with the exception of single personal endeavours like Richardson 1960 and 1972, for decades these questions did not attract much attention within the field of organisational economics (Coase 1988). However, in 1975, Williamson explicitly adopted the central idea of Coase by addressing the relative costs of organising transactions in *Market and Hierarchies*. Williamson (e.g. 1979) makes this basic idea operational by proposing a set of variables that

determine the cost of using the market, which in turn enables an analysis of the appropriate degree of coordination within firms.

In many ways this transaction costs perspective frames, if not shapes, central themes in recent contributions to coordination. One theme concerns *the variety of coordination modes*. In the early work of Hayek and Coase (and Williamson 1975) there are two modes and two modes only. And even though reduction of complexity is necessary in order to make theories “tractable”, their theoretical assumptions to some degree have to “correspond to the real world” (Coase 1937, p. 386) as well. By proposing *cooperation* as a third way to coordinate activities, Richardson (1972) was the first to give away a bit of “tractability” in order to gain a better fit with the real world. Later, several contributions on coordination modes beyond markets and hierarchies have emerged, as witnessed in for instance Williamson’s (1979) discussion of *Hybrid Forms*.⁹ A second, and closely related, theme deals with the underlying *variables affecting the selection of coordination modes*. Williamson (1979) addresses this theme by suggesting that variations in frequency and specificity explain the use of four different governance structures (including two hybrid forms).¹⁰

Thus, transaction costs theory has, in short, brought about significant achievements with respect to theories on coordination. And yet, its story is very incomplete. Although Williamson (ibid.) states that “the efficient

⁹ Many other names have been suggested for interactions that are neither purely market or firm based, for instance *collaboration* (Dodgson 1996, referring to Teece), *strategic alliances*, *partnerships*, *coalitions*, *franchises*, *research consortia* (Ring and Van de Ven 1992, p. 483), *Inter-organisational relationships* (Ring and Van de Ven 1994), *clans*, *quasi-integration* (Eccles 1981).

¹⁰ More precisely Williamson distinguishes between market governance, bilateral governance, trilateral governance and unified governance. The frequency and the specificity of the transaction determine the appropriateness of a governance structure. Frequency is simply a matter of how often the transaction takes place: “occasional” or “recurrent”. The investments are either characterised as “non-specific”, “mixed” or “idiosyncratic” (highly specific). The specificity of an investment is determined by the degree of non-marketable expenses incurred (Williamson 1979 and 1985); in this way specificity is a measure of the alternative value of an investment. *Market governance* is the main governance structure for both recurrent and occasional non-specific transactions. *Trilateral governance* is used for occasional and (medium and highly) specific transactions. *Bilateral governance* is used for transactions facing the same problems, caused by medium or high specificity, of relying on market governance as trilateral organised transactions. But the recurrence of transactions allows for more specialised governance structures, such as bilateral and unified governance, to arise. *Unified governance* is likely to be used for recurrent and highly specific transactions (Williamson 1985)

processing of information is an important and related concept” to “opportunism”, in its more formal part, transaction cost theory focuses mainly, if not solely, on the incentive part of coordination. As “one is struck by the absence of references to *incentive conflicts*” when reading Coase’s 1937-paper today (Foss 2000b, p. XX), so is one struck by the absence of information problems when reading Williamson and his successors. As observed by Demsetz¹¹ almost 15 years ago (1988, p. 144): “A more complete theory of the firm must give greater weight to information cost than is given either in Coase’s theory or in theories based on shirking and opportunism.”

This thesis is written very much in agreement with this proposition by Demsetz and subsequent writers who maintain that most formal economic analyses has downplayed the information perspective in favour of the incentive perspective (see for instance Milgrom and Roberts (1992), Bolton and Dewatripont (1994) and N. Foss (2000b)).

Additionally, this thesis will depart from the assumption that “agents” (e.g. individuals or firms) cannot foresee all future contingencies and cannot write contracts that cover all contingencies. Put differently, it will be assumed that it is for some or another reason costly to draft complex contracts – contracts are *incomplete*.

As seen in figure 1 below, combining the *incomplete contracting* and the focus on *non-incentive aspects of coordination* situates this thesis in a particular part of what has been labelled the theory of the firm; i.e. a body of theory that addresses the existence, the boundaries and the internal organisation of the firm (Foss 2000b):

¹¹ And echoed in Grandori (2000, Introduction Part II p. 9, italics added): “The classification ...[of eight coordination mechanisms]...is conducive to compare the capacity (and costs) of different mechanisms in governing the diversity of *interests* and *knowledge* among economic actors, under varying conditions of uncertainty.” More precisely, Grandori argues that if incentive and information aspects should be included or not cannot be determined ex ante, but depends on the object under investigation. Yet she defines information and incentives in such a way that coordination tasks not including both aspects are rare indeed (Grandori 2000, Introduction Part II p.p. 2-8).

Figure 1: “The theory of the firm” and the position of this thesis (bold letters)

	<i>Incentive conflicts crucial</i>	<i>No incentive problems</i>
<i>Complete contracting</i>	Nexus of contracts theory, principal/- agent theory	The Arrow-Debreau model
<i>Incomplete contracting</i>	The asset specificity and property rights perspectives	The coordination and information processing view

Adapted from Foss 2000b, p. xxxi

Hence, this thesis mainly perceives coordination in an information (and incomplete contracts) perspective. And as part of this, to a large extent, it draws on other theoretical contributions than offered by incentive based approaches such as, for instance, Williamson and his successors.¹²

I do not wish to claim, that incentives are unimportant to coordination or that nothing can be learned by using or expanding on a transaction cost perspective. However, as the information based approach to coordination has been somewhat neglected since transaction costs economics picked up steam some 25 years ago, and since I have only limited time and mental resources at my disposal, I have decided to focus on information aspects of coordination in the theoretical discussion that follows. Accordingly, the empirical analysis will also pay most attention to information aspects, even though incentive problems are occasionally referred to here if I, more or less coincidentally, have come across them.

Besides the empirical contributions, specifically I hope the information-based approach can advance our understanding within the following theoretical areas.

- *Theories of the firm I.* The information-based approach creates a challenge with respect to understanding the existence and role of firms as most theories of the firm have focussed on incentive aspects (N. Foss 2000 b). Thus, one specific contribution of this inquiry into theories on coordination is that it develops on a

¹² For a recent transaction cost analysis of the Danish Construction Sector, see Bang (2002).

broader view on why firms exist. As it will be argued, the information-driven and incentive-driven boundaries of the firm are not necessarily identical, but they are likely to have a significant overlap.

- *Theories of the firm II.* The existence of interfirm coordination besides “market and hierarchies” (to quote Williamson) has been acknowledged for some years. However, our knowledge on the specific forms interfirm-relations can take and what they are driven by is still limited. This thesis will elaborate on different types of interfirm coordination and take some initial steps towards an information-based understanding hereof.
- *Theories on how to coordinate I.* The discussion on the efficient use of alternative modes of coordination is not new. However, the present work will elaborate on how to handle coordination in a set-up that is likely to present in construction (i.e. a set-up with complex and non-repeated activities with many actors involved). Furthermore, the thesis will supplement existing theories by suggesting a learning based understanding of the efficient use of coordination modes.
- *Theories on how to coordinate II.* In some theoretical frameworks (for instance contingency theory as presented in chapter 3), the nature of the activities is taken for granted – the match between coordination modes and activities is simply a matter of choosing the right coordination mode. This thesis will suggest dynamic explanations to the interplay between coordination and activities as the organisational “design” of activities is an managerial option as well.

1.6. Summing up: Overall research question and main concepts

To sum up, the original question of this thesis was something like *why are certain modes of coordination selected for coordinating the activities involved in the process of building?*

In pursuit of this question, three empirical research questions have been identified. These questions will be dealt with in the following order (note that this sequence is different from the way they have been presented in the above).

- Research question A:** How is the division of labour in construction and what are the consequences hereof with respect to coordination?
- Research question B:** What are the roles of construction firms with respect to coordination: does coordination take place within or between firms and what limits that activities are handled within a single firm?
- Research question C:** What particular coordination modes are used for construction and how do they cope with the activities involved in construction?

Although the various concepts used in the research questions have been touched upon along the way, let me briefly recapitulate their meaning.

Coordination is (as mentioned earlier on) broadly understood as “*to make different parts function together efficiently*”. To phrase it in slightly more economic terms (and anticipating some lessons from chapter 2), coordination can be understood *as a process by which the actions of rent seeking individuals, each individual only possessing bits of knowledge, come into agreement with each other*.

As seen, the concept of coordination implies an evaluation of effectiveness and can be defined “as an improvement in the allocation of resources” (Casson 1997, p. 37) by some sort of criteria. Hence, *coordination* or *to coordinate* is a process towards an equilibrium in which “given resources are used in their best given alternative uses.” (K. Foss, 2001, p. 12). To *be coordinated* is a state in which such equilibrium is attained.¹³

By *coordination modes*, I refer to different ways in which this agreement between parts is reached. More precisely, since I apply an information based approach, I think of coordination modes as ways to structure information in order to cope with the problems of dispersed information

¹³ The distinction between coordination as a process and as state can be traced back to Hayek (1937). As a *state* (that perhaps is never reached) coordination can be defined as equilibrium (in the sense of *inter-compatibility*) of individual plans. And as a *process* coordination is a progression, where “the knowledge and intentions of the different members of society are supposed to come more and more into agreement” (ibid, p. 44).

(K. Foss 2001). The function of coordination modes is to minimise on information costs, including for instance the cost of transmitting information, cost of investing in information channels, cost due to error in communication, or cost of obtaining information through investigations (ibid.) as well as the cost of storage and processing of information (Casson and Wadeson 1999). The structuring of information can take many shapes; for instance, it can be forwarded by an intended act of communication or by instructions in a plan, it can be carried in flows of materials, or it can be imbedded in norms and rules settled through continuous interactions. All these various forms I consider as ways in which coordination is done and hence I do not restrict coordination modes to be statements about allocation of resources in the future (plans)¹⁴ or only to concern conscious actions. How all these potential forms of information structuring principles can be boiled down to a manageable typology, is reviewed in chapter 3 of this thesis.

Selection does not only infer deliberate choices made by management, workers or other decision makers. I also have less conscious processes in mind, such as trial-and-error processes and evolutionary “thinning out” of less appropriate, and thus less competitive, modes.

I perceive of an *activity* as a continuous performance of one or more tasks conducted by a single and rent seeking person using certain capabilities. This is done in accordance with Grandori’s (2000, chapter 1, p. 2) methodological proposition that “what matters for defining a unit of analysis... are analytical purposes. As she defines “an actor as a social entity in which no problem of interpersonal comparison of utility and of information transmission is considered to be relevant in relation to the problem being examined”, I define an activity in a way in which information transfer is not needed between persons (it is carried out by a single person) or over time (it is carried continuously). Here I assume,

¹⁴ Ménard (1994) declares that coordination “is quite generally defined so as to encapsulate the set of processes by which initially distinct plans are brought to a condition of compatibility”, and Casson (1997, p. 37) defines coordination “as an improvement in the allocation of resources”. And as a state K. Foss (2001, p. 12) also seems to agree with Hayek: “The economic meaning of coordination is to ensure that given resources are used in their best given alternative uses.” Although in many ways identical, one might sense a tension here between Hayek (and Ménard) on the one hand, and Casson and K. Foss on the other. The former uses the term “plans”, that is statements on future allocation; the latter simply talks about allocation.

which is of course a simplification, that there are no problems of information transfer and hence no scope for coordination between tasks carried out by the same person. Activities relate to production and could, if it was not too troublesome, be termed a *production activity*. The actions involved in coordinating these (production) activities, I have termed with other words than “activity” (or “task”, see below).

A sequence of activities can be within or between firms. The basic idea here is that the boundaries of coordination modes and the boundaries of the firm cannot be assumed to coincide. Hence, the organisation of coordination and the coordination modes are treated as two separate matters.

Two initial levels of analysis are related to *activities*: at the subordinate level *tasks*; and at the super-ordinate level *the value chain*.

An activity consists of one or more *tasks*, that is a process aiming at a tangible or intangible transformation of products or ideas along a value chain. In other words, I distinguish between activities and tasks. A task is a “unit of operation” that is not possible to separate for technical reasons (Grandori 2000, chapter 10, p.p. 4-5), or because skills or talents cannot be transferred (K. Foss 2000, p. 6). Hence, a task is given by the technology and skills involved in production – it is not a managerial option.¹⁵ However, an activity can encompass one or more tasks depending on how the overall process of production is decomposed. This is within the realm of management.¹⁶

A *value chain* is perceived of as the total number of coordinated activities resulting in an identifiable result (typically a product or service). A sequence of activities is a subset of a value chain. A value chain is identical to what Grandori (2000, chapter 10, p.p. 4-5) terms a *primary work system*.¹⁷

¹⁵ At least on a short and medium term. It could be imagined that in the long term the size of task would change as a response to, say, new technology and codification of skills.

¹⁶ It should be noticed that there is some confusion of how to employ the concepts *task* and *activities*. I have used the terminology of Grandori in which tasks are at a subordinate level of activities. K. Foss (2001, p. 6) suggests the reverse order and similarly does von Hippel (1990) perceive *tasks* as dependent on how a project is partitioned into smaller parts.

¹⁷ And identical to what Becker and Murphy (1992) term a *team*. However, I will never use the term

The *building process* is defined as the activities performed by the parties involved in the value chain that ultimately produces a building.¹⁸

For reasons unfolded in chapter 4 on method, empirically, I look at one particular housing project (a multiunit residential house) and in particular focus on the process of execution (and not on the prior process of planning or the subsequent phases of handing over and operating the final building). Within the execution phase, I zoom in on the activities and parties involved in roof construction (as roof construction is towards the end of the building project, it has the nice feature, that the way it interacts with other parts of the building is known, rather than only to be speculated upon).

A very narrow definition of *repetition* is not applied here because, as this thesis hope to show, repetition can penetrate from one level to another. Repetition will consequently refer to recurrence of different phenomena at different organisational levels. This is witnessed in the theoretical discussion (chapter 2, 3 and the beginning of 5) pointing out, that change ranges from the macro to the micro level and includes, among others: change in overall demand, change in available resources, change in technology, change in taste of costumers, change in sequences of activities, change in working relations, change in activities and change in tasks (Smith 1970, Thompson 1967, Van de Ven and Delbecq 1974, Groák 1992, Stinchcombe 1995).

1.7. *An outline of the thesis*

The thesis is structured as follows.

The aim of the theoretical part (chapters 2 and 3) is to provide a framework by which the three research problems are addressed. This implies, that the theoretical part is *not* written as if I did not know the construction sector. Rather, the theoretical part is targeted at understanding key characteristics of construction (as captured by the

“team” in the sense of a value chain since it can be misplaced by a specific coordination principle (Van de Ven 1976, Grandori 1997 and 2000).

¹⁸ Hence, civil engineering works – physical infrastructure such as bridges, roads, ports etc (Bang 2002) – is not included in this definition.

research questions). Hence, I have found it rewarding not to strive for a complete separation of theory and empirical analysis.

Chapter 2 relates to research problems A and B. Firstly, the major principles of the division of labour and knowledge are addressed in order to provide a basic understanding of the purpose of coordination (research question A). The following (and predominant) part of the chapter is devoted to the organisation of coordination (research question B). Emphasis is given to ways of organising that are found to be particularly important for non-repetitive interactions of activities: interfirm coordination, craft production and organisation in trades.

Chapter 3 addresses research problem C. Theoretical contributions on typologies of coordination are consulted. Secondly, the information costs of these different coordination modes are discussed. Again, special focus is given to situations that are characterised by high levels of external change: coordination of non-repeated activities, and supposedly following from this, complex activities with many actors potentially involved.

Chapter 4 contains reflections on method, for instance why a case study has been used, the methods used for data collection, and the subsequent scope for generalising the findings.

Since non-repetitiveness is argued to be of essence for the way coordination is organised and structured in construction, Chapter 5 is devoted to validating the claim of demand volatility in construction. The reasons for fluctuations on the sector level are briefly summarised and statistical data presented. This story is broadly known – however to this date, the way construction firms are affected by and coping with these overall changes has received less attention. By using data from a unique Danish database covering all companies in Denmark, this issue is explored. The database also gives some initial empirical indications on the research questions; in particular on research questions a and b relating to the division of labour and the role of interfirm coordination.

In chapter 6, the research questions are dealt with empirically at a less aggregate level. The majority of the chapter analyses the division of labour, organisation of coordination and coordination modes as observed in a case study of the construction of a roof in a multiunit residential house project. The chapter closes by briefly illustrating how

coordination takes place in sofa production (as argued in the chapter, sofa and roof production are in many ways alike, but they do differ with respect to repetition).

The theoretical discussion in chapter 7 begins with a review of the theoretical framework developed in chapters 2 and 3 in light of the empirical observations. As part of this, three propositions relating to the three research problems are proposed.

In pursuit of the research questions, elements of a more general understanding of the construction sector have been developed along the way. The empirical discussion of chapter 8 illustrates how this framework enables an understanding of a wider range of organisational characteristics of construction, than the ones studied directly as part of the three research questions.

Then the summary and conclusion follows in chapter 9.

The epilogue (chapter 10) includes reflections on how the construction sector might improve.

Appendix A is an introduction to the various phases and actors typically involved in house production.

Appendix B illustrates how social network analysis can contribute to a systematic understanding of the information costs of different coordination modes considered in chapter 3.

Appendix C provides additional statistical information to chapter 5.

INFORMATION BASED THEORIES AND PERSPECTIVES ON THE DIVISION OF LABOUR, ORGANISATION OF COORDINATION AND COORDINATION MODES

Introduction and outline

As argued, it is hardly possible to discuss the concept of *coordination* in any meaningful way without discussing the concepts of *division of labour* and *specialisation*. Without a division of labour there would be no need for coordination between individuals and in turn there would hardly be any specialisation within or among firms. And conversely, the division of labour and specialisation cannot be understood without considering the level of coordination costs by which they are limited (Becker and Murphy 1992).

In accordance with this mutual interdependence, the theoretical part consists of two chapters. Both chapters aim at presenting a theoretical framework for the research question on why specific forms of coordination are used during the process of construction.

The first chapter (chapter 2) pertains to the question of the division of labour and specialisation, i.e. *the organisation of coordination*. Hence, this chapter provides the theoretical framework for addressing **research question A** and **research question B**.

The next theoretical chapter (chapter 3) goes on to address the coordination modes (i.e. information principles) that can be used for coordination, *given* a certain division of labour and specialisation. This chapter relates to **research question C**.

Some basic trade-offs

Implicitly, the discussion on how activities should be organised and coordinated is based on the assumption that organisational design is about striking a delicate balance between a numbers of objectives, and that the exact position of these balances varies from one situation to another. The following theoretical and empirical parts implicitly refer to a number of such trade-offs.

At the very overall level, there is a *trade off between coordination and production costs*. If only production costs should be considered (and coordination costs are ignored) the remedy would be easy to give in

most situations: “increase the division of labour!”. Similarly, by reducing the division of labour, other things being equal, costs of coordination could be reduced. What naturally complicates things is, that both production costs *and* coordination costs have to be taken into account (Becker and Murphy 1992, Bolton and Dewatripont 1994).

Another trade off is between different temporal aspects of production and coordination costs. By focusing on one particular activity as well as creating fixed relations to neighbouring activities, it becomes possible to reduce production and coordination costs respectively. However, developing very specialised production and coordination capabilities and procedures often increases switching costs in case new activities and working constellations, for instance due to change in demand, are necessitated. Hence, there is a *trade-off between specialisation and adaptability*. The exact point of intersection is, among other things, influenced by the degree of stability (i.e. repetition) in inputs and outputs (Smith 1970).

For instance, firms that engage themselves in more permanent structures face a danger of surplus or lack of production capacity in case markets shift. However, due to repetition, structures that allow a “smooth” interaction between activities gradually develop and may, in spite of their inflexibility, be worthwhile to consider after all. Hence, one particular ramification of the trade-off between specialisation and flexibility is the trade-off between reducing the cost of production facilities *when in use* with the cost *when not in use*.¹

The cost of not having information versus the cost of getting information is a third kind of balance considered throughout this thesis. Acquisition of information reduces uncertainty (Arrow 1973, Galbraith 1973) and hence potentially enables coordination through an overall plan (in the Hayekian sense) in which the actions of each party are nicely fitted to each other. But it is not free of costs to obtain, transmit, absorb, process and store information (Arrow 1974). Hence, to some extent, it is profitable not to strive for complete information. An important implication of this is that there is an upper limit to how specified plans should be – the disadvantage of unplanned, and to some degree

¹ The same trade-off could exist between minimising costs of labour versus the costs of stocks.

unexpected, events has to be balanced with information costs involved in developing plans. Or to use coordination terms: the costs involved in the process of coordination have to be balanced with the costs involved in being in a less coordinated state: "An efficient economy achieves a given degree of coordination of material goods and services at minimum information costs" (Casson 1997, p. 36).

As the question of how coordination takes place unfolds during the theoretical part, a number of balances related to coordination in a more delimited field appear as well. Firstly, there is the trade off between different ways of organising coordination. As we know from Richardson (1972), coordination can take place within firms, on markets or (perhaps mediated by third parties) directly between firms. And similarly, as considered in chapter 3, the different principles (i.e. "coordination modes") by which coordination takes place have their comparative advantage for different kinds of information. Hence, to the degree that simultaneous use of coordination modes is impossible or very costly; there is a balance between handling different kinds of information. For instance, some coordination modes may handle the actions of many actors easily, but do so at the expense of nuances in the information exchanged. Other modes of coordination allow exchange of diversified and extensive information, but only allow interaction between a restricted numbers of actors.

A banal, and truly Smithian, insight developed throughout this thesis is that *repetition matters*. Or put more precisely, the location of the exact point of intersection for these trade-offs depends very much on the degree to which production activities – and the associated job of coordinating these – are done continuously or once only. For instance, flexibility towards producing new kinds of products is obviously not very important in ongoing production. And similarly, the cost of obtaining information becomes more and more negligible, the more activities it can be used for.

In this way, the work at hand brings some theoretical insights to an agenda that appears to be picking up steam these years: *temporary organisations* (or project organisations) as a distinct set of organisational forms very different from the ones traditionally found in ongoing production (Winch 1994).

Outline of theoretical part

Not surprisingly, chapter two on the division of labour and specialisation sets out with Adam Smith and his clarifications on the benefits of dividing production among individuals. It then takes us to Hayek and his idea about a *division of knowledge* as a result of this division of labour (section 2.1). Having identified why alignment of information is needed, it is pointed out, that the smithian division of labour obtained by repetition in activities, is facilitated by repetition in *sequences of activities* (section 2.2.). However, as repeated interaction implies commitment to specific persons and products, all relations cannot be maintained in fixed structures in case external change exists. And hence, some activities will be vulnerable to the unknown in- or output following from novel and non-repetitive interactions. In addition to the specialists in activities (or in *production*) outlined by Smith, this in turn favours the existence of specialists in handling of sequences of production (specialists in *coordination*) (section 2.3).

The benefits of having repeated sequences of activities (with the associated specialists in production and coordination) provide a *raison d'être* for the firm perceived as a *set of resources and activities*. This perception of the firm does not equal the (more common) *coasian* perspective regarding incomplete contracts and *authority* as hallmarks of the firm, nor the more recent property rights approach in which *ownership* is of essence. Yet, due to lower costs to *experimentation* and *decisive information*, it is likely that repeated interaction of activities significantly overlaps with the contractual and legal boundaries of the firm (section 2.4). However, the main contribution of Coase is perhaps not to explain the firm as such, but to explain *firms and markets* as two distinctive principles by which coordination can be organised (section 2.5). But, as Richardson points out (section 2.6), there are more nuances to the story than simply coordination by direction within firms or coordination between firms by markets. As argued in a modification of Richardson's contribution, in case specific products are produced under rapidly shifting (external) conditions, *interfirm coordination* of a more far-reaching character than market transactions arise. Since the generalness or specificity of products is crucial in order to understand the use of markets, section 2.7 addresses how standardisation of products can transform activities from being specific to general. As the establishment

of standards induces set-up costs or depends on learning from previous interaction, standards are less likely to emerge for non-repeated sequences of activities.

Thus, it seems that the job of coordinating activities in a non-repetitive setting is particularly difficult, as activities cannot be linked together in well-known sequences within a firm, nor easily can be made subject to market transactions, as they are not standardised. However, *craft production* and organisation in *trades* are ways of enabling coordination in this situation, even though the latter may also create *path dependency* (section 2.8). Finally, having identified the importance of interfirm coordination in particular in a non-repetitive setting, the chapter concludes by examining the different forms interfirm coordination can take (section 2.9). It is shown that bilateral coordination, which has been given much emphasis in the literature up to now, only is one out of several options. *Trilateral coordination* as well as *unilateral coordination with separate production* are other ways by which interfirm coordination can be coordinated. The advantages and disadvantages of these organisation forms are considered with particular emphasis on how to reduce information costs.

Chapter 3 addresses the question on how activities can be coordinated with a given division of labour and specialisation.

More precisely chapter 3 aims at 1) identifying *different modes* by which coordination can take place, and 2) the *pros and cons of these different coordination modes* with respect to alignment of different types and levels of information. The first aim is addressed by reviewing different conceptualisations within information based views on coordination modes, starting with the original statements of Thompson, then the refinements made by contingency theory, and concluding with the recent and synthesising work of Grandori. Then these different coordination modes are analysed according to their ability to handle different types and levels of information. Rather than addressing this discussion at a very general level, it is targeted to the specific ways of dividing labour and organising coordination that chapter 2 identified as the likely outcome of a non-repetitive setting. More precisely, the *use* of these different mechanisms is considered for situations with *low degrees of repetition in activities, many actors involved, and with high levels of information processing* (both quantitatively and qualitatively). This

combination is likely to favour certain modes of coordination as well as give them a particular shape. Finally, the chapter directs attention to the costs of *identifying* the most suitable coordination mode. As argued, these costs are considerable if repetition is infrequent and hence, stable coordination patterns - quite different from the one expected if only costs of using coordination modes are considered - can emerge.

Chapter 2 - the division of labour and organisation of coordination

2.1. The division of labour and knowledge

The Smithian idea of the division of labour is broadly known. However, since this concept in many ways is the foundation for discussing coordination, it seems worthwhile briefly to recapitulate the main insights offered by Smith.

Smith brings the division of labour centre stage at the very beginning of his book on *Wealth of Nations* (1970, originally 1776). “The greatest improvements in the productive powers of labour”, he explains, can be ascribed to this division (ibid. p. 109). More precisely, the benefits from a division of labour are threefold. Firstly, the increase of capabilities (“dexterity”) obtained by “reducing every man’s business to some one simple operation, and by making this operation the sole employment of his live” (ibid. p. 112). Secondly, savings in time spent on switching from one type of work to another. And finally, there is the innovation argument. As “Men are much more likely to discover easier and readier methods of attaining any object when the whole attention of their minds is directed towards that single object than when it is dissipated among a great variety of things” (ibid. p. 114), a division of labour promotes invention of machines that facilitate and partly substitute labour.

Knowledge, skills and experience (or what Richardson (1972) has termed *capabilities*) thus seem to constitute a core element in the division of labour. Not only do capabilities enhance the productivity directly for any given operation. Indirectly, capabilities about inventing and producing machinery also promote a higher yield of each man’s work. And hence, a division of labour coincides with different knowledge bases: the knowledge of the nailer is different from the knowledge of the black smith etc. Smith (ibid. p. 120) is very clear about the causality between the division of labour and different knowledge bases:

“The difference of natural talents in different men is, in reality, much less than we are aware of; and the very different genius which appears to distinguish men of different profession, when grown up to

maturity, is not upon many occasions so much the cause as the effect of the division of labour."

In other words, having people with different capabilities involved in producing a product, even a simple one like a nail, is an evitable part of the division of labour, according to Smith. Consequently, Smith basically argues that *dissimilarity* benefits individuals as well as society.

Smith highlights some of the fundamental benefits of a division of labour. Obviously, this raises the question of what, if any, the limits are to this division. Probably the most cited answer is that "the division of labour is limited by the extent of the market" (ibid. p. 121). However, Smith offers other explanations.

Firstly – and this is, as I shall argue throughout this work, of outmost importance for the construction sector – a discontinuity of operations limits the benefits from subdividing labour. Smith explains this with the example of agriculture compared with manufacturing. Due to the different seasons of the year, it is difficult for one man to be constantly working as a ploughman, a harrower, a sower of the seed, a reaper of the corn etc. Even though Smith stresses the importance of the seasons, his observation can be given a more general interpretation: the benefits from performing a single operation extremely well have to be traded off with the increased risk that this operation is not called for. The exact point of intersection between these two conditions of cause depends very much on the stability of production activities. In agriculture, the benefits of specialisation are (or at least used to be) low due to seasonal changes. In other sectors, like construction, it may be low due to other kind of changes, for instance changes in overall demand.

Secondly, the division of labour can only work with "the assistance and cooperation of many thousands" (ibid., p. 117). Even though Smith is not very explicit in this matter, the limits to the division of labour can also be ascribed to costs of coordination (Becker and Murphy 1992).

The latter point – the need for coordination due to a division of labour – is more directly addressed by Hayek (1937 and 1945). Alongside the division of labour, goes *the division of knowledge* (Hayek 1937, p. 49), which raises the problem of

"..how the spontaneous interaction of a number of people, each possessing only bits of knowledge, brings about a state of affairs in

which prices correspond to costs, etc., and which could be brought about by deliberate direction only by somebody who possessed the combined knowledge of all those individuals. (ibid. p. 49)

In principle, Hayek tells us, equilibrium – that is correspondence of plans – between actions can come about as a result of each person acting in accordance with an overall plan. But as indicated in the quote, making such a plan requires the combined knowledge of all individuals, a combined knowledge that does not exist in the outset due to the division of knowledge. One option is for all parties to agree on a plan in the beginning of a period of transactions, but this equilibrium is only obtainable, if assumptions on correct foresight of all parties are made. Otherwise, *changes* will make each member deviate from the plan in ways not longer ensuring coherence of actions (ibid. p.33-34).² Rather, in situations with changes and without correct foresight, the kind of equilibrium we can attain with dispersed knowledge is inter-compatibility of individual plans (ibid. p. 41).³

Two important observations can be learned from this. Firstly, by pointing out that the issue of coordination is essentially a matter of how knowledge is created and changed, Hayek makes clear, that coordination is essentially an *information* problem (even though Hayek in general do not use the term *information*). Furthermore, by using “intentions” as well as “knowledge” he also makes clear, that coordination is an incentive problem. Secondly, *change*⁴ – in combination with no correct foresight

² Hence, an equilibrium where the (subjective) data of each individual equals the (objective) data as made up by the totality of all individuals can only be reached, if assumptions on correct foresight are made.

³ Hayek (ibid. p. 42) gives this example of inter-compatibility of individual plans: “Consider the preparations which will be going on at any moment for the production of houses. Brickmakers, plumbers and others will all be producing materials which in each case will correspond to a certain quantity of houses for which just this quantity of the particular material will be required. If all these activities represent preparations for the production (and acquisition) of the same amount of houses we can say that there is equilibrium between them in the sense that all the people engaged in them may find that they can carry out their plans.”.

⁴ “It is, perhaps, worth stressing that economic problems arise always and only in consequence of change. As long as things continue as before, or at least as they were expected to, there arise no new problems requiring a decision, no need to form a new plan.” (Hayek 1945, p. 82).

and the division of knowledge – is located as a fundamental reason for the need for coordination. Hence, in order to analyse coordination practices used for a given set of activities – recall the research question – it seems worthwhile to consider the types and magnitude of changes imposed on these activities. Not only do changes affect the degree of specialisation (as outlined by Smith) and thereby the need for coordination, they also affect the need for coordination for a given division of labour (as outlined by Hayek). Chapter 4 starts out with a consideration of different types of change and how they relate to coordination in more detail.

2.2. Repetition in activities and repetition in sequences of activities

A fundamental lesson to be learned from the previous section is that repetition of identical activities is essential to the division of labour and in turn for growth. Consequently, lack of continuity in production is a threat to the division of labour, as illustrated in the Smithian (1970) example of how a farmer, due to seasonal changes, cannot focus on a simple activity.

Since disturbances are of outmost importance to the division of labour (and in turn coordination), the question of their origins and impacts, becomes of essence. Hence, in the following, I will go along with Thompson's (1967) idea that on one hand organisations (e.g. firms) are open systems facing external changes, but at the same time, as subject to criteria of rationality, organisations are able to create some stability in their operations.

A remarkable feature with Smith's discussion of the division of labour is that he does not address the way it is organised; for instance whether it is organised as fixed sequences of activities between specific persons or in more temporary relations. According to Demsetz (1991, p. 171) "It is safe to ignore the organization problem only if the gains achievable through specialization are independent of the way in which specialization is achieved". As it will be argued in the following, the way activities are organised indeed affect the extent to which each activity is subject to disturbances. Consequently, the organisation of activities has to be addressed in order to understand the division of labour.

Put differently, in order to understand repetition in activities and subsets hereof, we have to understand repetition between activities within a value chain. And, as it will be argued, in order to understand repetition between activities within the value chain, we will have to understand repetition between value chains. What is suggested theoretically and empirically in this thesis is that repetition at different levels is indeed interlinked and consequently that the analysis has to be the same.

The starting point for this analysis is that the well-known gains from repeating the same activity can also be applied to information processing involved in, for instance, coordination (Bolton and Dewatripont 1994). And hence, by repeating *sequences of activities* (and not only activities, as Smith is preoccupied with) *specialisation in coordination* can be achieved. Besides lower costs directly related to information processing, a potential benefit from this specialisation is the stability it brings to each activity. Thus, repetition in sequences of activities is a way to ensure repetition in activities.

The way repeated sequences of activities between the same persons bring stability to each activity relates to how

“Continuing association of the same persons makes it easier for firm-specific and person-specific information to be accumulated... Knowledge about the objectives and organization of the firm is learned “cheaply” through continuing association, and so is knowledge about the capabilities and limitations of the persons involved in this association.” (Demsetz 1991, p. 174).

Among other things, repeated sequences of activities create *shared expectations*:

“Shared expectations arise that provide psychological security, reduce the cost of information processing, and facilitates the coordination of different activities. Moreover, established conceptions of the way things are done can be very beneficial; members of an organization can use these stable expectations to predict the behaviour of others” (Powell 1991 quoted in Dubois and Gadde 2002).

Partly, these shared expectations relate to *qualitative* dimensions of coordination. For instance, if person B repeatedly receives input from A, over time he will be more and more knowledgeable about the nature of

the input and will be able to adjust his working operations accordingly. Further, as they interact repeatedly, it will be in the interest of B to inform A about potential improvements in the output from A (who possibly receives a higher price for his output). In addition, repetition can create shared expectations not only about the exchanged products, but also about the information going together with products. *Protocols* governing communication can economise on information costs, for instance by specifying a procedure for how much information should be exchanged, the content of the information, as well as the sequence in which it should be given. An important implication of such procedures is that no one is given too much or “double” information, nor too little or no information (Casson and Wadeson 1999). Finally, repeated interaction can allow for a shared language (March and Simon 1958) including coding of communication (Crémer 2000).

To some degree (and as discussed in the section on product standards towards the end of this chapter), shared expectations could also be obtained through general standards for interaction, that is standards that are not dependent on repetition between specific actors. However, some ways to standardise activities may be impossible or costly to transfer to other individuals or firms due to tacit elements of the knowledge, e.g. firm specific codes (Arrow 1974, p. 56) or “template knowledge” (Langlois 1999). As Demsetz (1991) phrased in the previous quote: human capital is often of high specificity.

Repeated interaction does not only enable an answer to the question of *what*, but also *how much* to transfer (the *quantitative* aspects of coordination). If A and B interact repeatedly, A will know how much he can allocate to B and correspondingly, B will know how much to expect from A. This reduces the costs of unused products (if A provides too much to B) or unused production facilities (if A provides too little to B). This problem becomes particularly important, when some units work most efficiently at certain volumes, since “techniques appropriate to large volumes cannot be “miniaturized”” (Langlois 1999, p. 243). Lack of “miniaturizability” creates the “balancing problem”: the equipment involved in the various phases of the process of production should be adjusted in accordance with the scale of production needed by the most discontinuous equipment (Grandori 2000). Fixed relations between activities are a way to ensure once and for all that the common

denominator (i.e. the volume at which all parts of the production works at it most efficient volume) is found and hence that the balancing problem is solved.

2.3. Specialisation in buffering

Thus, in many ways, repeated sequences of activities bring stability to the core of operation, i.e. to each activity. Yet, there are limits to the internalisation of activities in fixed structures. Continuing association implies commitment to particular firms and individuals producing particular products, and thereby induces inflexibility to new products. So, the efficient operation of long-term relations, for instance between activities, is dependent on the stability of the conditions under which they are operated (Bishop 1975, Demsetz 1991). Unless sources to instability are completely absent – which, as we learned from Hayek, is a questionable assumption – it will to some degree be necessary to split up the sequence of repeated activities.

In order to clarify this point, consider the distinction Casson (1997) makes on different types of change. One kind of change is associated with fluctuations in demand and supply within an established market. A second type of change relates to the breakdowns and disrupts in a sequence of production activities.⁵ In the terminology applied here, this will resemble change *between* and *within* value chains respectively

The previous sections of this chapter have considered change within the value chain. This section points out that the benefits of fixed relations at the level of the activity have to be balanced with the inflexibility to new products. And hence, that in order to understand specialisation and coordination within a value chain, change external to the value chain has to be considered. Correspondingly, Berger and Piore (1980) suggest that besides the extent of the market, *stability of demand* (and *uncertainty of demand*) has to be added to the list of impediments to the division of labour.

⁵ A third kind of change is the long-run structural change of the kind described by Schumpeter (Casson 1997).

According to Stinchcombe (1990), disturbances outside the realm of the single value chain can be caused by changes in (a) overall demand; (b) taste of customers; (c) technological development allowing new manufacturing principles and products; or (d) change in seasons or supply of raw materials. Casson (1997) makes, as mentioned, a distinction with some of the same elements; i.e. change between value chains (ad a) and long-run structural changes of the kind described by Schumpeter (ad c). Groák (1992) stresses ad a and ad d as important sources to instability.⁶

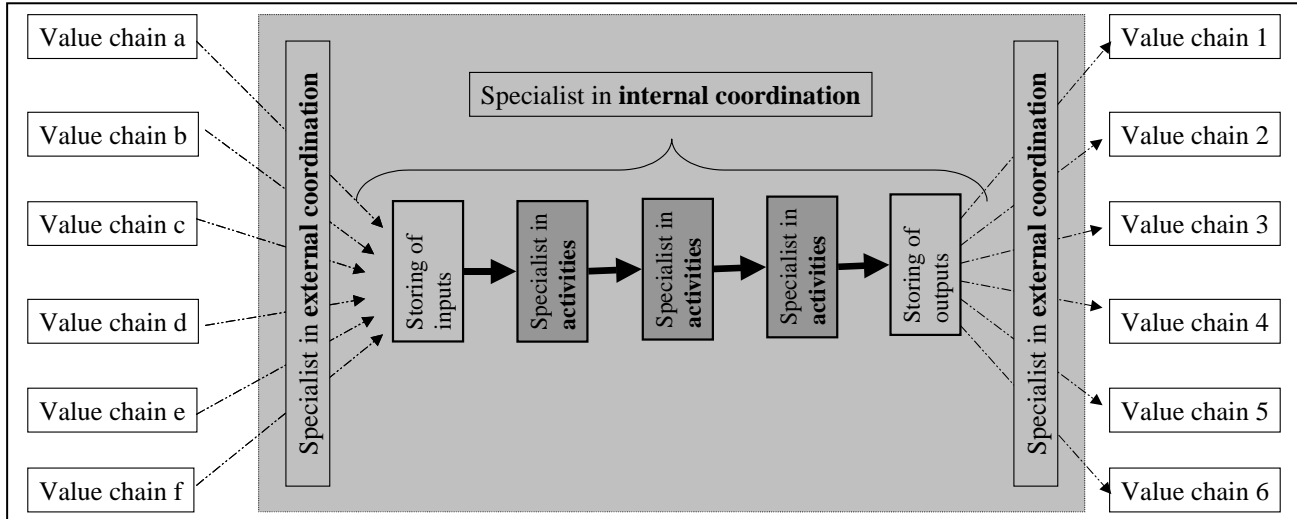
In order to adapt to these, or other types of external changes, some relations between activities have to be organised on a temporary and perhaps one-off basis, whereas other relations can be maintained in a repetitive structure. This implies that these sequences of repeated activities are open systems exposed to external changes. Thus, the question is how to operate activities placed at the vulnerable border of such interfaces. One possibility is to let the variations in input impact directly on the first activity in a sequence of activities and live with how these fluctuations propagate through the otherwise smoothly running chain of repeated interactions. However, this is hardly a strategy to follow for firms subject to rationality, taking the loss from low level of repetition in each activity into account. Presumably, some level of shock absorbing mechanisms in the outer positions of a sequence of repetitive relations of activities is profitable.

In this way, repetition in activities depends on absorption of variations in the adjacent activities. According to the general principles of the division of labour, this implies that “Organizations cope with uncertainty by creating certain parts specifically to deal with it, specializing other parts in operating under conditions of certainty or near certainty” (Thompson 1967, p. 13). Thus, some agents are engaged in production and others in the “higher-level” decisions relating to coordination (Hart and Moore 1999). For instance, the job of ensuring adequate supplies (in quantitative as well as in qualitative terms), may

⁶ Within the value chain Groák also emphasise *project uncertainty*, *workplace uncertainty* and *uncertainty of site organization*.

be taken care of by a purchasing department, whereas a constant sale can be the responsibility of a department specialised in selling (see figure 1).

Figure 1: Coordination and production specialists



Explanation: The bold arrows represent activities that are performed in repeated sequences. Specialists in production perform these activities. External changes in inputs as well as outputs makes constitute a potential treat to the continuous performance of these activities. In order to minimise this impact, specialists in external coordination switch back and forth between multiple value-chains (broken lines; it is coincidental that six alternative value chains are illustrated). Possibly, variations of this type can also be buffered by stockpiling (an option I return to in section 2.6). If external changes cannot be completely absorbed by these means, or if internal disturbances in production occur, simultaneous adaptations within the specific value chain are performed by specialists in internal production. The grey box represents an area in which persons interact repetitively. As argued in the next section, this area is likely to be identical to, or at least closely resemble, the contractual and legal boundaries of *the firm*.

Such buffering mechanisms exerted by specialists, absorbs fluctuations in demand and supply. In order to keep a constant rate and pace of production, it is the job of these persons to adjust to changes in the supply and demand for particular products by shifting back and forth between different value chains. Thus, the shock absorbing specialists have to ensure a high level of flexibility in products (both concerning the usable inputs and the possible uses after production) and at the same time allow rigidity in production.

In some situations adaptation to a change in the market can happen with no disturbance to production; in other situations more profound

adaptations have to be made. Changes internally in the chain of repeated activities may also call for a revision of the present organisation; for instance, if the benefits from a further specialisation in production are profitable to harvest or, as a more temporary phenomenon, if breakdowns in machinery (or personnel for that matter) causes a need for improvisation.

If, in the latter example, just a single activity has to be performed differently, it will most likely require simultaneous changes in most or all other activities in the repeated sequence of activities, as they have not been made independent, or almost independent, of each other. Hence, in case external disturbances impact on production, there is a challenging job of securing simultaneous change in a potentially large number of activities. And again, according to benefits from dividing labour, this may pave the way for persons – e.g. shop floor managers – specialised in creating concerted changes in production by changing the content of each activity or perhaps by redefining the boundaries of activities (and consequently, the way a product is divided into activities is, at least to some degree, “in fact a manageable process variable” (von Hippel 1990, p. 408)). Where the former group of coordination specialists handled changes *between value chains*, the shop floor managers or similar handle coordination *within a value chain*. To put it differently, if the value chain is portrayed horizontally, the first group of specialists in coordination deal with *vertical coordination* and the latter with *horizontal coordination*.

Thus, in short, it appears that in a world subject to change, in addition to the persons specialised in performing the very activities, persons specialised in handling disturbances are also likely to occur. This latter group may be decomposed into persons specialised in handling changes *externally* to the chain of repeated activities (persons with knowledge about different markets at the supply and demand side) and persons specialised in handling changes *internally* (people with knowledge on all the activities involved in production).⁷

⁷ This distinction resembles what Casson (1997) has termed changes *in markets* and *in production*, respectively. Casson discusses these two sorts of changes as separate matters, and even though it is not implausible that one type of change can exist without the other, as argued here, changes in markets (products) can foster changes in production. Whether the causality also runs the other way -

2.4. Repeated sequences of activities as an explanation to the existence of firms

So far, the benefits from organising in ways that allow for sequences of repeated activities of some length have been discussed and the groups of specialists involved herein have been outlined. It is tempting, and possible, to think of such a repeated sequence of activities and the associated specialist as *a firm*. In this case, the firm would be perceived as *a set of resources* (e.g. persons and equipment) *and activities*, which interact closely and repetitively (Grandori 2000). The fundamental reasons provided in the above for such a firm is one of information costs; firms are units specialised in “the essence of coordination”: *decision making* (Casson 1997, p. 76). By specialisation, improvement in decisions can be obtained, since the firm has the potential to acquire more or better information than the individual worker or consumer.

However, the information based “set-of-resources-and-activities”-perception is not the only theoretical explanation for the existence of firms. The firm described as a response to certain *incentive* problems is another - and according to Demsetz (1988) less ignored - perspective on the firm (See N. Foss 2000 b for an overview of different perspectives on the existence, boundaries and organisation of firms). According to the latter position, long-term binding contracts with residual decision rights, perhaps supported by ownership, are important hallmarks of the firm.

These legal or contractual definitions of the firm will possibly differ from the set-of-resources-and-activities-definition of the firm (Grandori 2000). Or, as clarified by Bolton and Dewatripont (1994, p. 810), when the firm is perceived as a communication network designed to minimize the costs of processing and transmitting information, the “...boundaries may be different from the legal boundaries of firms”.

Nevertheless, there may be a substantial overlap between on one hand repetition in activities and on the other hand the legal and contractual boundaries of the firm.⁸ In order to examine this, let us try to consider

changes in production will bring about changes in market – is not a trivial issue and will, with special focus on construction, be discussed in the introduction to chapter 5.

⁸ For matters of simplicity, I ignore the discussion about whether the contractual and ownership boundaries of the firm coincide. Grandori (2000) suggests that they as an outset should be treated as

which relation that most efficiently minimises on the information costs involved in the interaction between the previously outlined *specialists in activities* and *specialists in coordination of activities*.

To recall, it is the job of specialists in coordination to instruct the persons performing the very activities about the needed modification (irrespective of whether it is caused by internal or external changes). This information cannot be learned by the persons specialised in activities, as this will ruin the gains from specialised learning. And if changes not known in advance take place, it cannot easily be described *ex ante* in a contract.

This brings us forward to one (and perhaps the major) reason given by Coase (1937) on the reasons for the establishment of firms. When forecasting is difficult, it is less possible and desirable for the person to specify what the other party is supposed to do. Hence, rather than signing a very detailed contract subject to a market relation, it may be advantageous to form a contract where the exact details are left open until a later date. In this way an authority relation based on direction, i.e. the firm, is established according to Coase (*ibid.*).

K. Foss (2001b) develops this idea further by taking an explicit property rights approach, and by pointing out some situations in which detailed *ex ante* specification in a contract is difficult.⁹ Her argument is that - due to for instance unknown technological interdependencies created by an increasing division of labour - real markets rarely function as smoothly as assumed in neoclassical price theory (e.g. rights are not perfectly defined and transaction costs exists). Consequently, prices alone do not hold all the information required to ensure that no valuable resources are left idle. So, in particular when “an increasing division of labour introduces greater complexity and new kinds of tools and equipment and this in turn can create uncertainty about the best way of coordinating the specialized and interdependent tasks” (*ibid.*, p. 151), it “is impossible for managers *ex ante* to specify rights over assets and

separate matters. But in a property rights approach they are closely related as it is ownership that gives the residual rights of control on which the workability of an incomplete contract is based (Hart 1991, pp. 141-142)..

⁹ However, unlike Coase, but very much like the approach of this thesis, she does not take the costs of coordination activities or the extent of specialisation for granted (K. Foss 2001b, p. 153).

labour in such a way that each subtask fits optimally to all other tasks carried out" (ibid, p. 175).

In place of ex ante defined user rights over assets, *experimentation*, or learning by doing, is a way to learn about how to coordinate these activities. But, K. Foss continues, experiments with coordination of tasks are best facilitated by certain property rights, more precisely by *direction* (i.e. by *the Coasian firm*). The advantage of the firm can be ascribed to lower cost of (re)negotiation within a firm than between firms (ibid p. 164) and hence, the "centralisation of power has the advantage that one can make a decision involving many assets without having to obtain the consent of the owner of each asset" (Lando 1994). Or as Langlois (2001, p. 15) puts it: "When many different pieces of the system must be changed simultaneously to create new value, centralized control can often help overcome the narrow visions of the local participants, and centralised ownership can more easily trump the vested interests of those participants."

Notably, with this argument K. Foss substantiates why specialists in handling of *internal* changes are expected to be superiors (and *owners*) to the persons who performs the very activities (which we as a matter of convenience now safely can term *employees*). However, it should also be made clear, that this specific extension of the Coasian argument does not account for the hierarchical position of people specialised in *external* changes.

This aspect can be approached by Casson's (1994) discussion on *decisive information* as the reason for hierarchical firms. Decisiveness refers to a situation where for instance the choice between two strategies correctly can be based on information about some conditions irrespectively of the state of other conditions. And thus, if person A holds decisive information, he can act without contacting person B, whereas B would have to contact person A in order to make a right decision. Furthermore, if it is easier to communicate the decision than the information on which it is based, a hierarchical relation with person A as a superior to B will reduce the cost of communication. Based on this insight, Casson goes on to discuss whether firms are led by the market or led by design. The first situation is likely to emerge if decisiveness in demand is high and decisiveness in technology is low. For instance, if rapid changes in markets result in rapid changes in demand, and where fixed costs do not

require any particular level of production. Conversely, a situation led by design may arise in the presence of changes in (high level of) fixed costs and stable demand. In situations led by the market, the specialist in external changes will take a superior position to the specialist in internal changes, and vice versa in situations led by design. In case of a low or high level in both demand and technology – that is, in case no person is holding (more) decisive information (than another) – hierarchical levels between these two groups are not expected to arise due to decisiveness.

If the lower costs of experimentation due to common ownership are ignored for a moment (or are assumed to be of low value), the concept of decisiveness gives reason to consider if, in contrast with the argument provided so far, the specialist in activities could become superiors to the specialist in coordination. This situation could occur if the specialists in production had information on the performance of activities with crucial importance for the specialists in coordination (specialists in market and production changes respectively) and not the other way around. At least two conditions seem to be required in order to create such a situation. Firstly, changes internally in production have to be greater than changes in external markets. Whether this is the case is a question of empirical relevance, even though Casson (1994, 1997) suggest that, at least in the short run, demand tends to be much more volatile than production technology (implying that market led firms are more common than design led firms). Secondly, it should be the case that specialists in activities have information which cannot easily be obtained by specialists in coordination (if both parties have the information there is no decisiveness). As it is the job of specialists in internal coordination to design, observe, and redesign (and perhaps also to monitor) all the various activities involved in production, these specialists usually have a fairly accurate picture of the conditions under which the specialists in activities operate. On the other hand, since the job of specialists in activities is to perform, well, exactly activities and not to coordinate the behaviour of others, it is less likely that specialists in activities have a comprehensive view of the doings of specialists in coordination.

Hence, reducing information costs in case information is decisive does not necessarily imply, that specialists in coordination are superiors to specialists in activities. However, it seems to be the most likely outcome. And if so, in combination with lower costs to experimentation, the

presence of decisive information could account for why specialists in activities are employees and specialists in coordination are superiors and (perhaps) owners of the firm.

2.5. Coordination by firms and markets

Departing from Coase's seminal contribution, *The Nature of the Firm* (1937), the previous section has offered reasons why repeated sequences of activities are likely to correspond with the contractual and legal notion of the firm. However, his article - published the same year and journal as Hayek published "Economics and Knowledge" (1937) - does not explain the existence of firms in itself, but describes firms *and* markets as two fundamental ways by which coordination can take place. Outside the firm, price movements direct production, whereas the entrepreneur-coordinator directs production inside the firm. According to Coase, the use of these two supplementing yet distinctive concepts is determined by their relative cost (Coase 1937). So even though the price versus planning based coordination outlined by Hayek is reminiscent of Coase's distinction, Coase identifies two mechanisms that both can be found in non-socialists economies. None of these mechanisms are given any supremacy in the outset. Rather, their respective fields of action have to be determined by a comparative assessment of their respective costs for a given situation.

Information costs play a critical role in this comparative assessment. The costs of using the market are dependent on the cost of discovering the relevant prices, as well as on the cost of negotiating and concluding a contract for each transaction. Forming a long-term contract may reduce the cost of the latter and a firm is likely to emerge (ibid. pp. 390-391). Finally, as mentioned, when forecasting is difficult, a contract where the exact details are left open until a later date may be preferable. The costs of using the firm are largely dependent on the number of transactions, since (a) the costs of organising additional transactions within the firm may rise and (b) the entrepreneur fails to place the factors of production in the best possible way (ibid. pp. 394-395).¹⁰

¹⁰ Even though Coase devotes some space to this issue (see in particular pp. 396-397) it is not very clear in *The Nature of the Firm* why the cost of organising an extra activity within a firm should rise

Thus, Coase provides one of the earliest discussions of how coordination can and should be organised. The fundamental idea of markets and firms as *the* two principles by which coordination can take place was later taken up by Williamson in *Market and Hierarchies* (1975). Williamson (1979, 1985) makes this basic idea operational by proposing a set of variables that determine the cost of using the market, which in turn enables an analysis of the appropriate way to organise coordination.¹¹ In this way Williamson put the transaction cost perspective on track and as part of this, in contrast to Coase, directed theorizing on coordination towards *incentive* aspects. As explained in chapter 1, I do not pursue the line of reasoning offered by the incentive based coordination literature, but focus primarily on information-related aspects of coordination. Consequently, the (substantial) contributions of Williamson and his successors are not addressed further in this theoretical part.

2.6. Interfirm coordination

The discussion presented so far suggest that, dependent on the stability of the conditions under which they are performed, activities can either be conducted in repeated sequences or in temporary relations. The former is expected to take place within a firm (in which decisions are based on direction by an entrepreneur), the latter is expected to take place on a market (in which decisions are based on prices). Further, part of the cost of using the market relates to the costs of discovering the relevant prices, as well as the costs of negotiating and concluding a contract for each transaction. In addition to these costs *ex ante* and during a transaction, *ex post* costs of reinforcing a contract could also be imagined (Dahlman 1979, Coase 1988).

more dramatically than the cost of organising an extra activity in the market. However, as discussed in chapter 3, authority is vulnerable to information overload and is consequently, other things being equal, affected more by an additional activity than coordination modes working with more local knowledge and decisions.

¹¹ An important implication of this is that (vertical) integration, given the right circumstances, may be desirable not only in the view of the firms, but also at a more aggregate societal level (with the following consequences for anti-trust policy) (Williamson 1987, p. 807-808).

Richardson (1972) expands on this idea of different costs for the use of markets by distinguishing between different *types of products*. Some products have a wide, general purpose and as a result, it is possible to apply the law of large numbers (the market) as a principle of coordination. Other products have a more particular purpose, thus making quantitative and qualitative coordination necessary since demand is far from predictable.

The relation between size of the market and the need for coordination can be related to the condition that individual stochastic factors tend to average out in large samples whereby a steady quantity of goods are produced and consumed (Casson 1997). Furthermore, as markets become “thicker” (bigger), the cost of buffering product-flow uncertainty by for instance stockpiling is reduced (Langlois 2001).

This distinction represents one part of Richardson’s argument about why there are more nuances to the story on the organisation of coordination than simply direction within firms or coordination by prices between firms. The distinction between identical or different *capabilities* constitutes the other half of the argument. In short, the argument goes, that in case different capabilities are involved in production of specific products, interfirm coordination of a more far reaching - with respect to duration and information involved - character than market transactions arises.

Thus, Richardson acknowledges markets and firms as two important means for coordination. And as Coase, he defines the market - as opposed to the firm - by including “no obligation with respect to the future conduct” (ibid. p. 886) of a buyer and seller.¹² However, future obligations do not necessarily equal a firm, since future obligations can also be established between firms. Richardson terms this kind of interfirm coordination *cooperation*. Cooperation differs from markets

¹² Note that the definition of markets offered both by Coase (1937) and Richardson (1972) appears to be rather limited as it only encompasses “here-and-now” relations. A wider definition of market contracts could, besides of pure spot market contracts, also include order contracts, piece rate contracts or employment contracts; contracts that aside of the spot market contract, contain some instructions, restrictions or are accompanied by orders. In this wider view, the difference between markets, interfirm cooperation (in the sense of Richardson) and the firm (in the Coasian sense of employment contracts based on residual user rights) is thus a matter of degree (K. Foss 2001c).

because it entails obligations for future conduct, but at same time differs from firms because these obligations are restricted in scope and often also in formality (ibid. p. 886). One of the prominent features of cooperation is that it in contrast to markets allows for not only quantitative (how much to exchange) but also for qualitative coordination (what to exchange); Richardson considered the latter especially important in case of development of products and processes (ibid. 885).

The scheme is that not all activities involved in a product are similar with respect to the capabilities involved. In line with the explicit penrosian position taken by Richardson, capabilities are essential to patterns of integration since "...organisations will tend to specialise in activities for which their capabilities offer some comparative advantage; these activities will, in other words, generally be similar..." (ibid. p. 888). Similar activities are activities requiring the same capability.^{13 14} Despite the fact that activities based on different capabilities are not easily placed within a firm, they nevertheless need to be coordinated, since they add up to a product. These kinds of activities are termed *complementary activities* by Richardson.¹⁵ Thus, Richardson constructs a simple matrix,

¹³ This does not imply that organisations always will be arranged according to capabilities. Risk spreading can be another consideration leading to conglomerates (Richardson 1972, p. 889).

¹⁴ The tendency to integrate within similar capabilities does not imply, that the organisations will work solely within one market, since the same capability can be useful in different production activities. As observed by Penrose, the traditional product based approach to the firm seems inadequate in explaining the existence of the multiproduct firm. Instead she suggests that the "...flexibility and versatility of its [the firm] resources are the important factors governing the possibilities of its expansion" (Penrose 1959, p. 539). In the same way – and with direct reference to Penrose – Teece (1996) argues that a firm capability lies in a generalizable capability that might well find a variety of final product applications.

¹⁵ The distinction is identical to what Richardson (1960) terms *complementary investments*, that is investments by which the profitability of an investment (or in 1972-terms: an activity) is increased by carrying out another one; which is the case, for instance, "where the output of one firm provides a raw material or intermediate product for the manufacture of another". This kind of interdependence is different from the "form of interdependence [that] derives from the fact that any form of production generates income, and therefore demand for other goods" (Richardson 1960, p. 31). Accordingly, table 1 informs us about coordination of activities that are related in the sense that they, at least potentially, are part of the same value chain. Table 1 does not inform us of coordination between value chains that are only related by income.

which indicates factors determining the appropriate mode of coordination.

Table 1: Coordination by markets, firms and (interfirm) cooperation – the “capability view”

		Similar activities (= same capability)	Complementary activities (= different capabilities)
General products	purpose	⁻¹⁶	<i>Coordination through markets</i>
Particular products	purpose	<i>Coordination through direction (the firm)</i>	<i>Coordination through (interfirm) cooperation</i>

By introducing the notion of capabilities, Richardson constitutes a framework that can explain the existence of arrangements beyond markets and hierarchies. Undoubtedly, the notion of capabilities (and interfirm relations) has gained momentum since then (Langlois & N. Foss 1997), even though (or perhaps because) the concept of capabilities is not well understood in theoretic terms, nor is easily made operational (N. Foss 2000 c).

In light of this, and without passing any final judgement on the soundness of a capability based approach, let me propose an account for the existence of “cooperation” that in a way is very close to that of Richardson but at the same time is more consistent with the approach taken here as the concept of *capabilities* are replaced with the concept of repetition.¹⁷

¹⁶ Richardson does not address what happens when similar activities produce general purpose products. In principle both market and direction could be imagined as modes of coordination whereas coordination by cooperation is hard to imagine because there is no need for quantitative and qualitative coordination when a general purpose product is produced.

¹⁷ Even though I do not pursue a capability approach as such, I share the view that issues of information and coordination, and not only of incentive problems, are important to understand, among others, the boundaries of the firm. And indeed, in the following chapter (chapter 3) I discuss the contributions of Marschak and Radner (1972), Arrow (1974) Bolton and Dewatripont (1994),

The left hand side of the matrix is identical to Richardson's: when products are general, through market transactions it is possible to coordinate activities in a way that is both flexible and that allows each activity to be performed with minimal disturbances. However, if products have a more particular purpose, stochastic factors do not average out and quantitative and qualitative coordination is necessary. Repeated interaction within a firm is a way to obtain such coordination, but - as pointed out in the upper part of the matrix - the benefits of repeating sequences of activities have to be traded off with a loss in flexibility. Hence, when the (intermediate) products are of high specificity and when conditions are rapidly shifting (for instance due to change in quality or quantity requested by customers), it is not possible to coordinate activities on a market or within a firm. But if the activities are part of the same product, they nevertheless have to be coordinated, potentially by interfirm cooperation.

Thus, an alternative version of the drivers between Richardson's three different ways of organising coordination can be suggested (table 2).

Table 2: Coordination by markets, firms and (interfirm) cooperation - the "repetition view"

		Activities performed under nearly stable conditions	Activities performed under rapidly shifting conditions
General products	purpose	-	<i>Coordination through markets</i>
Particular products	purpose	<i>Coordination through direction (the firm)</i>	<i>Coordination through (interfirm) cooperation</i>

Notice that this matrix is identical to the matrix proposed by Thompson in 1967 (with reference to Dill 1958). However, where Thompson (ibid, pp. 72-73) uses this matrix to explain intra-organisational differences,

authors which according to Langlois and N. Foss (1997, p. 27) "...will become increasingly important as first steps towards the formalization of capabilities ideas."

here it is used for explaining external boundaries to organisations (e.g. firms).

In sum, when conditions are unstable and products are particular, neither markets nor fixed sequences of activities appear to be attractive solutions. In this situation “cooperation” can be an alternative.

2.7. Some elements in a more dynamic approach to firm and interfirm coordination: The creation of product standards

In the previous section it was argued, that coordination can be organised in three different ways: in firms, in markets or by long-term cooperation between firms. Further, it was proposed, that general purpose products hold many advantages to specialised ones, as a wide applicability of products makes it possible to lower quantitative and qualitative variations in inputs at low costs (thereby enabling the division of labour).

So far, the specificity of products has been treated as an independent value. However, if the applicability of products is so crucial to coordination as outlined, it would be expected that firms or others engage in a process of turning particular products into more general ones. Thus, this section is devoted to the analysis of how and why market standards emerge. As it will be argued, the degree to which such standards emerge is, at least in the outset, likely to be favoured by some level of repetition between specific actors. Thus (what at first may appear paradoxical), standards which enable a disintegration of repeated activities over time through the ease of markets, are, at least in initial periods, also promoted by repeated activities.

The purpose of addressing the dynamics of specificity in products is to give a more thorough understanding of when we are likely to observe coordination by firms, markets, or by interfirm cooperation. As it will be argued, interfirm cooperation is expected to be particularly profound when repetition in production is low.¹⁸

¹⁸ A similar argument for how a low level of repetition enhances the level of interfirm cooperation can be provided with respect to Richardson’s original capability/product matrix. As for the specificity of products, Richardson is not very explicit about what causes capabilities involved in producing a

2.7.1. The emergence of product standards as an information economising device

Product standards¹⁹, or standards as I shall simply term them, are often an attractive way to enable coordination, since they allow each production activity to be performed in an efficient manner and at the same time involve few direct coordination costs (Thompson 1967, Casson 1997). As a written or unwritten classification of products agreed on by two or more parties – on matters such as size, content, the way the product has been produced, performance and perhaps also terms of delivery – standards are a way to ease, or lower, knowledge transfer between activities within the firm (firm standards) or between firms (market standards). They also enable the very act of tangible or intangible transformation, since the input is well known and can be processed without prior investigation and without further specification of the output. Standards can also take the shape of dies that further reduce production costs by fixing which tools and working procedures to use (Langlois 1999, p. 248).^{20 21}

product to be different or not. Yet, as Smith clearly stated, we would expect different capabilities used for even the “simplest” products since the creation of different capabilities according to Smith is one of the very reasons why it is advantageous to specialise. In other words, Smith argues in favour of more differentiation in capabilities (as an outcome from specialisation). However, as argued previously in this chapter, the design of activities is to some degree subject to the control of managers. Thus, managers can choose to design activities in a way so that they are based on identical, closely identical or at least not hard to combine capabilities and hence capabilities that can be maintained inside the firm. But, to recapitulate, the benefits of grouping strings of activities together within a firm have to be counterbalanced with the need for flexibility. Hence, if activities are performed in unstable conditions, the possibility of engaging in repeated interactions, and hence defining these activities by particular capabilities, is limited.

¹⁹ “Product standards” are the quality standards that describe minimum attributes or characteristics of a product. Hence, in product standards I do not include standards pertaining to the interface of multiple products (compatibility standards) (Grindley 1995). Furthermore, I do not consider standardisation of work practices or of capabilities as a part of product standards (Mintzberg 1979).

²⁰ The concept of standards relates closely to the concept of economics of scale. As witnessed by Langlois, three explanations to economics of scale are dominant. The first (1) is the Smithian division of labour, where economics of scale mainly is seen as the result of learning curve effects obtained by increased “dexterity” as a result of increased repetition. The two neoclassical arguments are: (2) the substitution of larger and more specialised machines and (3) fixed factors or overhead (Langlois 1999, p. 241 and pp. 244-245). Explanation number two, Langlois argues, can be boiled down to explanation

Standards made common to a market do not only reduce the amount of qualitative information involved in coordination. As standards smoothen the process of searching for products and of specifying terms for exchange (i.e. lower transaction costs), the market becomes “thicker” and able to buffer product-flow uncertainty (Langlois 2001, pp. 31-32). In very large markets the effects of individual stochastic factors averages out, whereby a steady quantity of goods are produced and consumed (Casson 1997, p. 12). In smaller, but not small, markets the averaging out of stochastic factors can possibly be supported by *stockpiling* or similar ways of buffering variations in in- and outputs. Of course such buffering mechanisms induce storage costs, but these are also reduced by an increasing size of the market.

In general, standards reduce the quantitative and qualitative information involved in coordination. And hence, by a process of standardisation, products can change from being “particular purpose products” to being “general purpose products”. Following the idea of Richardson, standards thereby reduce the extent of interfirm coordination. Or, as phrased by Langlois and Foss (1997), standards change a system from being *systemic* (requiring simultaneous change in many parts of a system) to become more *autonomous* or *modular* (change can take place in one subsystem without greatly affecting other subsystems).

More precisely, the firm with the highest benefit is expected to engage in such market promoting activities (Loasby 1994). However, the creation of standards is dependent on whether the standard is firm, interfirm or sector specific (i.e. public standards). It is unlikely that firms will engage

three, and this explanation can again be explained by the process of growth of knowledge. This is due to the fact that *standards* are a fixed cost as well as “...reusable pieces of knowledge that emerge from the process of learning about production...” (ibid, p. 247).

²¹ The concept of “standards” is closely related to the concepts of “modules” which can be perceived of as a “...abstract fundamental unit of measurement which, by means of multiplication, subtraction or division, numerically determines the geometrical system of a given modular order” and by this enable coordination (Wachmann 1961, p. 54). Modules (and standards) can take many different forms as witnessed in the modular categories identified by Wachmann (ibid p.p. 55-75): material module, performance module, geometry module, handling module, structural module, element module, joint module, component module, tolerance module, installation module, fixture module, and planning module.

in public standards on their own due to problems of free-riding. Consequently, one would expect these to be introduced by third parties, such as trade organisations or governmental institutions. However, firms may create public standards in a process where specific standards at first are located within or between a limited numbers of firms. Over time, these standards may outdo other standards (and perhaps firms) and become dominating in the entire system.

Thus, standards ensure low variable costs to coordination of succeeding units of production within or, in case they are market-wide, between firms (Langlois 1999). But does this render the concept of interfirm coordination by cooperation irrelevant? Hardly, because there are conditions that have to be met before standardisation in the form discussed above is profitable or perhaps even possible. Standards can be “reusable pieces of knowledge that emerge from the process of learning about production” (Langlois 1999, p. 247). If so, some degree of continuity is required in order to allow learning to take place.²² An alternative to this reuse of knowledge is creation of standards *ex ante* a transaction. But again, standards involve set-up costs. For instance, standards have to be invented, disseminated and none the least, understood or by other means made possible to use by the various parties operating in the market. Therefore, *ex ante* definition of standards also requires some degree of repetitiveness in order to be profitable (ibid.).

2.8. Repetition, craft production, trade organisation, and path dependency

So even though the specificity of products is not a static variable and as such can be affected for instance by means of standardisation, interfirm coordination, in the sense of “corporation”, is expected to exist. As argued, it is likely to be promoted by a low level of repetition in

²² In this way standards can be a particular way of institutionalising knowledge transfer made profitable by ongoing interactions: “When change is continuous then institutions will emerge to channel information routinely in an appropriate way. The process of change becomes embedded in institutionalized procedures” (Casson 1997, p. 10).

sequences of activities (that in turn can be ascribed to external changes of some sort).

It would seem that the job of coordinating activities across firms in such a fluctuating environment would be enormous as there (a) are no or little standards to reduce information; (b) multiple parties without prior knowledge of each other are involved; (c) the scope for specialising in particular sequences of activities is limited, and consequently; (d) activities are not easily defined in a way that enables coordination.

However, there are means by which coordination can be less troublesome even in this set up. Of these, I will particularly focus on (I) sector-wide standard interfaces between groups of firms and individuals, each group “equipped” with homogenous capabilities (in the following simply termed “trade organisation”); and (II) the use of highly skilled labour (“craft production”).

Craft production is a mean to reduce the interdependence of activities. In case of a high level of standards, the input (and output) of an activity is without significant deviations from one time to another. And since the activity can be performed in exactly the same way every time, the level - or more precisely the width - of capabilities is minimised and eventually transferred to machines (Smith 1970, Langlois 1999 and 2001). On the other hand, if the input as well as the required output varies from one operation to another, a much wider spectrum of capabilities is needed. In principle, managers could possess these capabilities, but the costs of instructing workers for each and every activity favour that a substantial part of capabilities are in the hands of the workers. Hence, variations in input and output are not buffered by the managers’ control of work flows, as in standardised - and often highly capital intensive - interactions, but are allocated to the individual stages of production (Langlois 2001, p. 19).

Craft production replaces standardization of work-processes and output with standardisation of skills (Mintzberg 1979). Thus, the idea of “craft” (Stinchcombe 1959) or “artisanal” production is that the highly skilled worker “buffers the variation by acting as a high-quality information-processing unit” (Langlois 2001). By reducing the need for information of the actions of other parties (that is reducing the amount of coordination),

it compensates for the high “unit cost” of information due to among others lack of standards.

The rationale of *trade organisation* is to replace lack of repetition at one level with repetition at another and more aggregate level. As seen, the interaction between specific people and firms is not expected to be high when fluctuations in, for instance, demand favour flexibility more than specialisation in specific relations (within a firm or between particular firms). Since new working constellations are constantly formed, firms and individuals have limited possibilities of, or interest in, knowing each other. This can create a significant problem of *lack of expectations*. As the idiosyncrasies of each counterpart is not known, the interaction can vary in a close to infinite number of ways and make it impossible to provide structures in which only the deviations from a usual procedure (and not all elements of the procedure) is reported (Casson and Wadeson 1999). Thus, lack of expectations seriously increases the cost of handling information. Accordingly, it may be advantageous to establish common expectations not at the firm or (the specific) inter-firm level, but for a wider group of firms and individuals.

The trade organisation is an example of how common expectations can be created at a sectoral level (through what might be called *isomorphism*). Here, all the parties involved in production are grouped into a limited and clearly recognisable number of groups. Each group, i.e. each trade, have particular but homogenous capabilities. An important element of creating this homogeneity can be *common skills* obtained by a shared and rather thorough education. As firms tend to specialise in activities for which their capabilities are similar (Penrose 1959, Richardson 1972), supposedly one group of firms employs workers with one set of capabilities, another group of firms employs workers with another set of capabilities etc. The absence of firm specialisation within the trade enables the mobility of employees within this group, resulting in high levels of *common experience*. As the individuals within a group are homogenous with respect to capabilities, expectations not only within, but also between the groups can arise even without prior knowledge of the specific counterparting firms or individuals.

So, even though specialisation and the division of labour is curtailed, it can be in the interest of firms and individuals to give up (or not to develop) their idiosyncrasies in order to establish not great, but shared

expectations. Thus, in situations where expectations are not easily created and used on the level of the firm, there can be benefits from isomorphism, i.e. using a single way of organising a larger group, for instance a sector. The more a single design is used the better, as competing ways of organising reduce shared expectations.

To the degree that it is beneficial to use a single way of organising, i.e. the degree to which returns are increasing and not constant or diminishing, this potentially creates *path dependency*.

Path dependency inform us that even in the long run, inferior solutions are not necessarily outperformed by less inferior solutions. First of all, insignificant or random events in early periods can give a certain way of organising a lead early on, and as it can be beneficial to stick to a single design, this can eventually drive out the others. Small events do not average out and the development can be very difficult to predict in the outset. But at the same time, as a single design becomes dominating, the system becomes less and less flexible. So gradually the system becomes less and less unpredictable with the following benefits of shared expectations. However, the lock-in that the system eventually reaches at is not necessarily the one with the best long-run potential. This relates to the fact that decisions and conditions, which seemed reasonable or unimportant in early periods, later can have consequences of which there was no knowledge *ex ante*. Or because early developers did not take the long-term consequences, which they might envisioned, but for which they did not expect to be compensated, into account (Arthur 1989).²³ The invention of the QWERTY-keyboard is a vivid example of this (David 1985).

To illustrate, consider the following possibility (that can be perceived as some elements in a very rough working hypothesis for the historical development of construction): In the outset, the choice between, on the one hand, a system based on firm specialisation and, on the other hand, a trade system is a close race between the benefits of specialisation versus the benefits of shared expectations. The conditions initially favoured (a particular kind of) trade organisation, but later changed in favour of specialisation (or another type of trade organisation). For instance, a

²³ Arthur considers competing *technologies*, whereas I consider competing *organisational designs*.

higher level of income in society and better physical infrastructure later increased the extent of the market, which encouraged specialisation (Smith 1970). However, as the trade system became dominant, it reinforced itself. For instance, as firms were not specialised, the mobility of workers increased, which in turn lowered the degree of firm specific investments in training of the employees. It also reduced the possibility that firms could define activities in such a way that they could be kept in-house. This in turn lowered the benefits from firm specialisation and hence made a shift from trade to firm specialisation less likely.²⁴

Of course this illustration is highly speculative. However, the potential existence of path dependence is important to have mind when discussing the organisation of construction in general and in particular when considering room for improvement in this sector.

2.9. Different types of interfirm coordination

Until now, the theoretical inquiries have addressed some major principles in the division of labour and specialisation, and pointed to the existence and reasons for interfirm coordination. This has developed a theoretical frame for addressing research question A and partially B. Interfirm coordination has been discussed in the vein of Richardson as a question of markets, firms or interfirm cooperation. However, this does not pre-empt the field of possible and existing (as the discussion of the construction sector will show) ways by which interfirm coordination can take place, and as part of this, the question of *third party coordination* raised in research question B has not yet been fully addressed.²⁵

²⁴ Conversely, at the same time as standards on products depend on repetition, they increase repetition since the impact from variations in possible inputs and outputs are reduced (Langlois 1999, p. 25). Thus, it is likely that a positive circle of standardisation can be established: with some level of repetition in the outset, standards are established that again increase repetition that in turn enables standardisation etc. Therefore, if standards for products had become the dominant design it might have reinforced itself in the same way as the trade organisation.

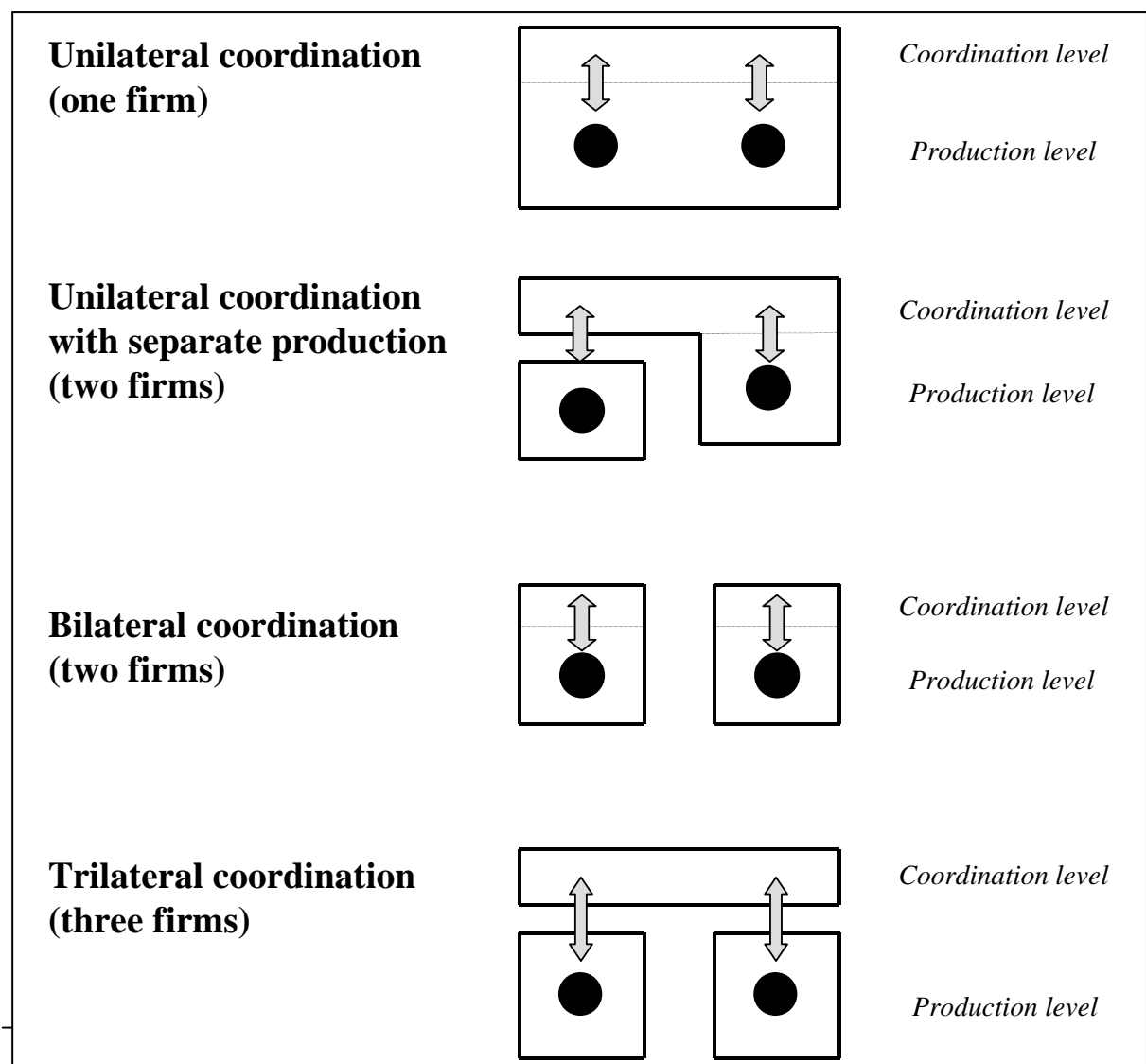
²⁵ Most likely it does not give full justice to the different ways market and intrafirm coordination can be organised either. However, since my main concern is to understand especially inter-firm coordination, I do not pursue these aspects in the following.

In order to broaden our view on interfirm coordination, let us recall the basic notion of the firm discussed throughout this chapter: a firm – irrespectively of whether it is considered a repeated set of resources and activities or by ownership and residual contracts - consists of (a) production activities and (b) actions of coordinating these activities. If we, for the purpose at hand, accept this view of the firm this leaves four possible options:

- I. unilateral coordination,
- II. unilateral coordination with separate production,
- III. bilateral coordination, and
- IV. trilateral coordination.

These different forms are illustrated in figure 1.

Figure 1: Four types of firm and interfirm coordination



So far the discussion so far has been preoccupied with coordination of types I and III. Coase (1937) discussed unilateral coordination (firms) versus bilateral coordination (markets). Richardson (1972) pointed out, that bilateral coordination can be of a more binding character than the one known from markets. K. Foss (2001b), Casson (1997), and Casson and Wadeson (1999) focused on unilateral coordination by clarifying why, and under what conditions, this way of organising activities is superior to bilateral coordination.

But what about the other two: when and why would we expect to see *unilateral coordination with separate production* or *trilateral coordination*? (From the construction sector we know that they exist. For instance, the general contractor who carries out one trade on the building site but coordinates all trades on behalf of the client is an example of the former, the pure design and build contractor is example of the latter).²⁶

Let me conclude this chapter by reflecting on this question by pointing to some potential advantages and disadvantages of coordination by a third party firm. (I also return to this question in the beginning of chapter 8, where some of the more overall theoretical implications of the empirical findings are discussed).

To recapitulate, low repetition makes it more difficult to manage coordination as strings of activities within a firm. Bilateral coordination in the sense of Richardson (that is, long- or medium-lasting relations directly between two firms, including quantitative and qualitative coordination) is one way to organise in this setting. However, even though the duration of these interfirm relations are shorter than when organised within the firm, they nevertheless rely on some degree of repetition. And presumably, in case the conditions under which activities are performed are extremely unstable, even bilateral coordination by cooperation is too rigid.

²⁶ In Denmark three mains forms of procurement are common: (a) a separate trades contract where the client make direct contracts with both consultants and contractors; (b) main contracts, where one contractor (the main contractor) coordinates the behaviour of the other (sub)contractors on behalf of the client; and (c) design and build contracts where one contractor coordinate subcontractors and consultants on behalf of the client. See Bang 2002, chapter two, for at more thorough introduction to different contractual relations in construction.

Hence, situations of great instability favour that firms and individuals interact in one-off relations (i.e. coordination is not organised within or directly between two firms). If products do not have a general purpose, coordination through markets does not appear to be an attractive alternative. In this setting, coordination by a third party can hold comparative advantages.

As there is very limited room for repetition of specific relations, it makes little sense to specialise here. In particular not if a trade organisation is used (as discussed in the previous section). Because the interfaces are (almost) identical from one project to another irrespectively of the specific firms or individuals involved, a person or a firm can specialise in coordination without knowledge of, and thus without repeated interaction with, specific counterparts.

This line of reasoning suggests that there are no compelling reasons why specialists in internal coordination should be a part of the firms that carry out production. On the contrary, placing specialists in internal coordination in separate firms can be beneficial for a number of reasons.

Going back to the insight of Penrose (1959) and Richardson (1972), it is difficult to bridge different capabilities within one firm. Other things being equal, this favours that specialists in activities and specialists in coordination are placed in different firms. However, it is also possible to account for the existence of firms specialised solely in coordination, without including the (somewhat dubious) notion of capabilities.

An important part of the job of specialists in internal coordination is to process information about external changes and subsequently translate them into adequate modifications of the value chain. Placing this function within a single firm rather than in all the firms involved in production, reduces costs related to *duplication* of information. Hence, coordination by a third party is a way to reduce information and decision costs related to interfirm coordination between multiple firms (Grandori 2000). That a substantial number of firms are expected to be present in situations, where little external stability does not favour integration of subsequent activities, accentuates this argument.

In addition, if incentive based reasons (for once) are included, direct negotiations directly between two parties can be difficult to settle in case of strongly divergent objectives. Here, arbitration by a third party can be

a favourable solution (ibid.). Furthermore, assigning the responsibility for the overall design to one party can be a safeguard against solutions that favour some part of the value chain at the expense of other parts.

Thus, to specialise in coordination holds some advantages. However, compared with bilateral coordination, third party coordination has drawbacks as well. Hands-on experience from production does not enable innovation of new working processes and machineries, as realised by Smith (1970). Hands-on experience also provides important information about coordinating aspects: what to coordinate, when to coordinate, between whom etc. Due to these partly unanticipated spillovers, it will often be cheaper for a producing party to obtain this information, than for a third party to focus solely on coordination. Secondly, the separation of production and coordination can bring about conflicting incentives as well. It is in the interest of each of the producing firm to pass on exactly the information to the coordinator that ensures an efficient - from each firm's point of view - coordination. The asymmetric information created by the lack of hands-on experience stresses this possibility. And conversely, since the coordinating firm is not taking part in the production process, it may be in their interest to "under-invest" in coordination.

The invention of new production techniques is likely to face problems in third party coordination. Compared with unilateral coordination, there are difficulties in bringing about simultaneous change in a number of firms not subject to centralised control and ownership (K. Foss 2001b, Langlois 2001). Compared to bilateral coordination, it is more costly to transfer knowledge on these new techniques to a coordinating party without "hands-on" experience. Furthermore, it is not necessarily in the interest of the coordinating party to take new techniques, which enable production, but do not take the job of coordinating into account.²⁷ In this perspective, *unilateral coordination with separate production* can be seen as a

²⁷ The premise for this discussion is that the price/quality ratio is difficult to estimate for the final costumer. If not, he or she will be able to buy another product or specify the price for a given product. In this case, production systems with less sub-optimisation will eventually rule out more sub-optimised systems. Hence, the experience of the final customer, as well as the degree to which the final product is standardised, seems important to consider in order to access the (mal)functions of a coordination set-up.

way of balancing the benefits of specialising in coordination with the benefits of “hands-on experience.

In conclusion, it appears that firms can act as coordinators in three distinct ways: (a) as coordinators of *market changes* as well as *value chain changes* (e.g. the role of the firm in unilateral coordination); (b) as coordinators of changes in markets, but not within the value chain (e.g. the producing firm in trilateral coordination); and (c) as coordinators of changes in the value chain, but not in markets (e.g. the coordinating firm in trilateral coordination). As argued in this and previous sections, firms of type *a* are expected to be dominant when low levels of external changes allow activities to interact repetitively. Firms of type *b* and *c* are expected to become more dominant as activities approach a one-off relation.

Chapter 3 – The selection of coordination modes

The previous chapter provided a framework for understanding why a division of labour arises, the need for coordination created by this, and some of the ways in which coordination can be organised. However, we have not yet addressed the different information structures (coordination modes) used in order to overcome the problems of dispersed information.¹ Hence, there is some way to go before we can engage in an empirical analysis of the research question on *how* to coordinate activities involved in the process of house construction.

It is this discussion of coordination modes that I will embark upon in this chapter. More precisely, the aim of this chapter is twofold. First of all, in order to distinguish between different modes of coordination, we need some sort of typology. A typology however, does not further an understanding of the efficient application of alternative coordination modes and thus does not explain why particular modes of coordination come into play in construction. Hence, a second objective of this chapter is to provide a framework that captures the comparative advantages of different coordination modes. In the information perspective applied here, this is to understand how the modes differ with respect to their ability to handle information.

3.1. Views on a coordination mode typology

This section addresses the issue of the different principles by which coordination can be done. The starting point is Thompson's work *Organizations in Action* from 1967. Thompson is included because much of the subsequent work within the information-based perspective to coordination can be traced back to the way he conceptualise coordination modes, and the way he subsequently links coordination modes to different informational situations. Thompson is one of the originators to a wide range of contributions developed mainly in the 1970s under the label "contingency theory", which I will consider next. From this view, I extract the way contingencies are made operational by

¹ "As well as different incentives" one might argue. However, as the focus of this thesis is on information aspects of coordination, incentive aspects have been given less attention.

considering different informational characteristics of an activity. I then make a rather large historical, but not conceptual, jump to the recent work of Grandori (1997 and 2000). Grandori is included because she tries to encompass the work on, among others, contingency theory into a more overall categorisation of coordination modes in which information plays a critical role. Furthermore, Grandori is unique in the sense that she provides a rather systematic assessment of the advantages and disadvantages of handling information by these modes. Hence, she does not only make important contributions to an information-based typology on coordination modes, as discussed in this section. She also facilitates an understanding of the efficient application of alternative coordination modes, as discussed in section 3.2.

3.1.1. Coordination modes and drivers according to Thompson

An early contribution on different coordination modes with distinct information handling capacities was introduced by Thompson (1967). His central idea is to explain the workability of different coordination modes with the different ways activities can be interdependent on each other. Thompson does not claim this to be new; he makes explicit reference to *Organizations* by March and Simon (1958) in which the need for joint or not joint decision-making depends on different forms of interdependence. Accordingly, the coordination-typology used by Thompson is a (very mild) modification of Simon and March (1958, especially pp. 181-82).

It is with respect to the concept of interdependence that Thompson makes the perhaps most obvious extension of Simon and March.² Rather than using the concept of “mutual dependence” and “interdependence of timing”, he introduces the following:

- *Pooled interdependence*, referring to a situation where activities belong to the same system, while not being interdependent in any direct way. It can be described as a situation where “...each part renders a discrete contribution to the whole and each is supported by the whole.” (Thompson 1967, p. 54).

² However, this is probably not the most fundamental difference. The explicit use of learning in March and Simon and that organisations can define activities themselves are probably of a more far reaching nature as illustrated in the empirical analysis of this thesis.

- *Sequential interdependence*, describing a direct, non-symmetrical, relation between activities; for instance, activity 1 has to be carried out before activity 2 can proceed.
- *Reciprocal interdependence*, characterising a direct and ongoing symmetrical relation between two activities: Activity 1 depends on activity 2 and vice versa.

Thompson then goes on to relate these interdependencies with types of coordination. The implicit assumption seems to be, that the informational complexity corresponds to this directionality (i.e. the three types of interdependence) in a clear-cut (and in the order mentioned, increasing) way.³ Pooled interdependence should be coordinated through *standardization*, involving “the establishment of routines or rules which constrain action of each unit or position into paths consistent with those taken by the others in the interdependent relationship” (Thompson 1967, p. 56). With sequential interdependence, *coordination by plan* – such as work schedules – is suitable. And finally, with reciprocal interdependence, *coordination by mutual adjustment* (or by *feedback*) is suitable, encompassing “new transmission of information during the process of action” (Thompson 1967, p. 56).

Even though the three different mechanisms for coordination cope with the respective interdependencies, they do so at different costs: “...coordination by mutual adjustment is more costly, involving greater decision and communication burdens, than coordination by plan, which in turn is more costly than coordination by standardization.” (ibid. p. 57). And hence, “We would therefore expect first priority to be given to grouping in such a way as to minimize the most costly forms of coordination” (ibid. p. 57). This gives the guttman-type scale summarised in table 1, where “all organizations have pooled interdependence; more complicated organizations have sequential as well as pooled; and the most complex have reciprocal, sequential, and pooled” (ibid. p. 55).

³ Grandori (2000, chapter 8, p. 30) strongly disagree with this implicit assumption: “What complicates and makes the effective coordination mechanisms qualitatively different is not the bidirectionality of the relationship per se, but the non-predictability of the relationship and the need to resolve new problems – that is, the information complexity of the relationship.”

Table 1: Coordination and interdependencies according to Thompson

Type of interdependence	Mode of coordination	Information and decisions costs / difficulties of coordination
Pooled	Standardisation	Low
Sequential	Plans (+ standardisation)	Medium
Reciprocal	Mutual adjustment (+ plans) (+ standardisation)	High

3.1.2. The contingency view on coordination

Organizations in Action inspired a number of empirical and theoretical studies conducted mainly in the 1970s. *Contingency theory* is the label often used to classify these related contributions (Lorsch and Lawrence 1970, Galbraith 1973, Adler 1995). “Contingency” refers to the idea that the best way to organise is contingent upon a set of variables that differs from one situation to another (ibid., Mintzberg 1979). Hence, a key element of contingency theory is to locate different forms of contingencies and assess their impact on organisational forms in general and coordination modes in particular.

As we know by now, the main contingency considered by Thompson is *interdependence* – when the type of interdependence is known, so is the appropriate way to coordinate it. Contingency theory expands on this idea by proposing different aspects affecting the degree of interdependence:

- *Task complexity*⁴ (Van de Ven 1973), *task diversity* (Galbraith 1973) or *task difficulty* (Van de Ven and Delbecq 1974) refers to the degree of difficulty in the search process, the amount of thinking time, and the knowledge required to perform the task.

⁴ Van de Ven uses “tasks” for the work done by a “work unit” that is the smallest formal grouping of individuals within an organisation. Thus, the concept of tasks is used at a more aggregate level than the definition of tasks than I use (recall chapter 1). In order to avoid confusion with the definitions used in chapter 1, in the sections that follows, I will use the term “*activity complexity*” in stead of “*task complexity*”, “*activity variability*” in stead of “*task variability*” etc.

- *Task variability* refers to the number of different cases encountered in work. Hence, task variability relates to the stability and uniformity of inputs and outputs (ibid.).
- *Task uncertainty* is seen as the combination of task complexity and task variability by Van de Ven (et al 1976). However, Galbraith (1973) conceives it as a contingency in its own right characterised by the degree to which it is known in advance and can be preplanned, or conversely, if it is not well understood *ex ante*, the degree to which information must be processed *during* task execution.⁵
- *Size of work unit* simply refers to the total number of people of a work unit (Van de ven *et al* 1976). Restricting the question of number of people involved in coordination to the work unit makes sense for Ven de Ven (*et al*, 1976), who sole focus is on coordination within this unit. However, in more general terms, this contingency can be understood simply as the total number of people involved in coordinating a given set of activities.

Even though activity complexity, activity variability, activity uncertainty and size of work unit are presented as (three or four) autonomous concepts, they are obviously related. For instance, without activity variability there would be no activity uncertainty (whereas no activity uncertainty does not imply no activity variability). As we know, the division of labour, by which each person deals with a delimited activity in which he becomes particular skilled, is a way to reduce activity complexity. However, the benefits of a division of labour depend on the level of repetition, that is a low activity variability. Hence, activity variability promotes activity complexity. If activities cannot be performed as pre-planned due to activity uncertainty, they become more difficult to execute (Galbraith 1973). Conversely, high levels of activity complexity can often be traced back to a number of contingencies interacting in a way that is not easy to analyse. Thus, what makes them complex to perform can also make them difficult to pre-plan. Similarly, many different actors (size of work unit) can enhance the cost of

⁵ As I will return to in section 3.2.2, the disagreement can perhaps relate to two different dimensions of task variability. The first dimension relates to task variability at any given point of time (stressed by Van de Ven). The second dimension relates to task variability from one period to another, and as part of this, the possible of knowing this change *ex ante* (stressed by Galbraith).

searching, as well as processing information and thereby increase complexity. In short, these reflections suggest a (often positive) correlation between the concepts of activity complexity, activity variability, activity uncertainty and size of work units.

These contingencies are by contingency theory hypothesised to favour particular organisational forms and coordination modes. With respect to the latter, contingency theory expands Thompson's view on coordination modes. Firstly, new coordination modes – of which *teaming* is probably the best known – are proposed. Teaming refers to situations where work and activities do not only flow back and forth (as in Thompson's reciprocal interdependence), but are done at the same time within a group (Van de Ven *et al* 1976). Secondly, a number of refinements are made (for instance if coordination is done in an impersonal, personal or group mode; if it is done in a planned or unplanned way; by vertical or horizontal relations within the firm (*ibid.*)⁶; by centralised or decentralised decision-making (Van de Ven 1973); or by rules and programs, hierarchy or goal setting (Galbraith 1973); or by highly or less educated personnel (Van de Ven and Delbecq 1974).

3.1.3. Interdependencies and coordination modes – two different interpretations of the direction of causality

As the names suggests⁷, contingency theory considers the contingencies as independent variables, for instance determined by the environment (Lorsch and Lawrence, 1970). It is in general not perceived as a possibility, that these can be affected by deliberate actions of, for instance, managers. Rather, the contingencies tend to be perceived as innate characteristics of the activities and/or the sectors in which they are performed (see box 1). Not surprisingly, strategical advice focuses exclusively on how to identify and act according to, say, interdependencies (see for instance Mccann and Ferry 1975 and Malone

⁶ A point of view that was later developed by Aoki (1986 and 1990), who discusses hierarchical control versus horizontal coordination. The former is supposed to be typical for American manufacturing firms, whereas horizontal is predominant in Japanese firms.

⁷ Contingency means “event that may or may not occur; event that happens by chance” (Oxford Advanced Learner's Dictionary)

and Crowston 1994) and not on how these interdependencies are created.

However, as witnessed by the very structure of this theoretical part, and as indirectly discussed in the previous chapter, this is a very one-sided version of the story on the interplay between coordination modes and interdependencies. Since the way a product is portioned into activities to some degree is a manageable process (von Hippel 1990) it makes sense to start from an analysis of the effectiveness and efficiency of the boundaries of organizational units before examining coordination modes (Grandori 2000).

The latter view suggests a much more active role of management (centralised or not) than the one of simply adjusting to given contingencies. As work processes can be partitioned in different ways, management has the option to influence the division of labour and hence the need for coordination. Naturally, the size of this managerial scope is not infinite to the firm. It will depend on a wide range of conditions like, for instance, the kind of technology available, the specificity of costumers demand, and the actions of other firms. And if these conditions change over time, the exact room for manoeuvre is furthermore time-dependent, but none the less, some degrees of freedom are present.

In line with this approach, I would like to propose that, within limits, one managerial option is to define activities in such a way, that they minimise on information costs. For instance, by designing activities in a way in which the output of an initial activity determines the completion of subsequent activities, the cost of instructing employees can be minimised. Or, as another example, activities can be defined in ways in which errors are more easily discovered in subsequent steps of production (by which efforts spent on assessing the quality of input is narrowed).

The extension of the contingency view I offer here is in line with the more overall classification of coordination modes proposed by Staudenmayer (1998). In a survey of the literature on interdependency, she identifies four theoretical approaches (or “paradigms” as she phrases them). The first approach considers interdependencies as a matter of *information processing* which arises as a consequence of inherent aspects of the tasks and technology, and hence interdependence is depicted as an independent variable. According to Staudenmayer, this position is

represented by contingency theory as initiated by Thompson (1967). Another approach, in agreement with the proposal offered here, argues that interdependencies reflects the *organizing choices made by management*: “The very acts of defining tasks and allocating them across individuals and sub-units...create different interdependencies in an organization.” (ibid. p. 4). A third approach focuses on scarce and valued resources that create interdependencies as people *compete* for these resources. By stressing difference in interests, this approach is related to the incentive perspective to coordination that, as discussed in chapter 1, is not in focus in this thesis. The final approach to interdependencies relates to more cognitive aspects, emphasising the interdependence of knowledge and belief structures. According to Staudenmayer, an important element of this interdependence is how people come to *recognise* interdependencies. I discuss aspects of this approach below under the label of costs of *identifying* coordination modes.

Box 1: The contingency view on determinants of interdependencies – The example of Thompson (1967)

Thompson proposes that organisations can, and should, adjust their coordination modes according to the interdependencies. But what about the interdependencies; where do they come from according to Thompson? Well, they are determined by the kind of technology used for producing different products, he seems to answer.

To see this, we have to consider Thompson’s conceptualisation of *buffering*, *smoothing*, *adaptation*, and *rationing* as ways to cope with shocks (Ibid., pp. 20-23). *Buffering* absorbs environmental fluctuations by surrounding the technical core with input and output components. A way of doing this is to stockpile supplies or output. Buffering brings considerable advantages to the technical core, but at the same time induce storage costs. A second option is *smoothing* fluctuations by affecting the environment. For instance, lowering prices in low-peak periods can reduce variability in the use of electricity. Similarly, fines can be introduced if services or products are not delivered on time. *Adaptation* is a third option. In case changes in environment can be foreseen, they can be incorporated in plans or schedules and the technical core is only mildly affected. Unanticipated fluctuations interfere more seriously with the operation of the technology and thereby reduce its performance. In case none of these shock-absorbers work, *rationing* is the only option left for securing an organisational part some degree of stability. But it is “an unhappy solution, for its use signifies that the technology is not operating at its maximum” (Thompson 1967, p. 23). Either the production facilities are idle in low-peak periods or/and there is waiting time in high-peak periods.

(Continues)

Even though Thompson is not very explicit on this matter, the four shock-reducing methods presented here obviously relate to the three different coordination mechanisms and the associated types of interdependencies previously described. Adaptation works through plans and schedules and is clearly associated with the coordination mechanism of planning. Coordination by standardisation requires rather stable and repetitive situations, which seems to be best honoured by buffering. Smoothing is an ongoing interaction with the environment (for instance by informing about price-levels in low- and high-peak periods) and in that sense it resembles coordination by *mutual adjustment*. However, Thompson has a rather extensive interaction in mind, when he discusses this coordination mode (for instance, he describes it as something that is done in crews or teams, *ibid.* p. 58) and hence the congruity between smoothing and mutual adjustment is only partial. Finally, *rationing* is the outcome if none of the three other coordination modes work.

Finally, the shock absorbers relate to three different kinds of technologies. The principle of buffering “is especially important for mass-manufacturing organizations” (*ibid.* p. 20), where mass manufacturing, at least in the form of the mass production assembly line, is a *long-linked technology* (p. 16). Another type of technology is the *mediating technology* that has to meet the needs of multiple clients by working in standardised ways. Thompson mentions banks and post offices as examples of mediating technologies (*ibid.* p. 16) and also makes clear that banks and post offices often work by plans or schedules (*ibid.*, p. 22), in other words are coordinated by planning. And finally, there is the *intensive technology* where the order by which production techniques are used is determined by the feedback from the object itself. However, he does not clarify which kind of coordination mode this kind of technology associates with. One possibility is mutual adjustment (which seems to fit well with the idea of that this kind of technology works by low degrees of repetition); another is coordination by rationing (which seems consistent with the fact that “therapeutic” technology, the kind of technical logic used in the construction industry according to Thompson, is coordinated by this mode (*ibid.* p. 23).

This line of reasoning seems to propose the following. Firstly, since interdependencies are rooted in a few different types of technology, all firms using a particular technology must be expected to coordinate their activities in similar ways. For instance, all mass manufacturing firms coordinate by means of standardisation and nothing else (whereas all post offices and banks are expected to use an identical blend of planning and standardisation etc). Secondly, unless it is assumed that management can change from one basic type of technology to another, the role of management is to adapt to given interdependencies by choosing the corresponding coordination modes. Changing the interdependencies or making firm-specific combinations of coordination modes does not appear to be an option in the “Thompsonian” framework. As I return to later in this chapter and in the discussion of theoretical perspectives (chapter 7), this is a very limited interpretation of the role the firm may play in the process of coordination.

Box 1 : The contingency view on determinants of interdependencies – The example of Thompson (1967). Continued.

3.1.4. Coordination modes and drivers according to Grandori

Contingency theory stages the work of Grandori in two important ways, considered in the following. Firstly, by introducing a wide range of concepts related to coordination as well as coordination modes, that are all found to be important, but that do appear to be integrated into a coherent framework. Secondly, by stressing that choosing the right coordination mode, or other organisational forms, is not simply a one-dimensional choice of, for instance, being more or less interdependent (as Thompson proposes). As many contingencies have to be considered simultaneously, finding the right coordination mode, or combination of coordination modes, is a subtle exercise, which includes the danger that not all contingencies can be handled.⁸

The four coordination modes developed partly by Thompson, partly by Van de Ven, was considered on a nearly 1:1 scale in a paper by Grandori and Soda (2001). However, Grandori's main elaboration and synthesis of a wide range of literature on coordination unfolds in her principal work *Organisations and economic behaviour* (2000), as well as in an article from 1997. In the subsequent discussion I will rely mainly on these latter sources, in which a more multi-faceted typology of coordination is developed.

In short, Grandori's ambition is to move towards an exhaustive typology based on explicit and non-contradicting assumptions. One of the assumptions she modifies is the Coasian idea that the principles used for coordination are not equal to the organisation of coordination. Grandori thereby makes clear, that the same kind of coordination mode can be found within as well as between firms.⁹ And since Grandori (unlike Thompson) does not only consider coordination to be an intra-firm phenomenon, her typology covers more ground than that of

⁸ Contingency theory also contributes a large empirical programme developed in particular by Van de Ven and Ferry (1980) in which propositions of Thompson and successors are tested empirically. As an important part of this, concepts are made operational for empirical studies. However, since the aim of this chapter is to provide a theoretical overview and discussion, here I focus on the theoretical contributions.

⁹ Imai and Itami (1996) point to a similar conclusion in their concept of "interpenetration".

Thompson's. Furthermore, she includes a lot of nuances added since the original statements of, say, Coase – often from areas outside the limited circles of economists – and thereby she moves far beyond a simple market-firm continuum.¹⁰

More precisely, she outlines eight different archetypical mechanisms, grouped in four pairs, by which coordination can take place:

- *Price*¹¹ and *vote* coordination. Using common codified¹² information (i.e., price), each agent makes up an independent decision based on his local knowledge of his own productive or consumption capacity. Besides price, no information is transferred between agents. *Voting* resembles price coordination in the sense that it is based on local knowledge and local decision-making. Here, each agent maximizes by choosing between a numbers of well-defined alternatives.¹³
- *Authority* and *agency* coordination. In the case of *authority*, according to centralized managerial knowledge and transfer of information, a central agent makes decisions on, and control of, subordinates' behaviour. This coordination mechanism is consequently based on the premise that the central agent has the capacity to handle the information required for directing (and monitoring) the behaviour of subordinates. If this condition does not obtain, *agency* can serve as an

¹⁰ In this way Grandori see herself as an exponent of the view, that it is necessary to move beyond the dichotomised view on governance structures. Including the notion of a third type of governance, like "clans", "trust", and "networks" is clearly a step in the right direction, but it is not sufficient: "to reduce the number of alternatives to two or three is to under-evaluate our cognitive capacity to a considerable extent" (Grandori 1997, pp. 29-30).

¹¹ Since "The market as a governance system is constituted by a larger and more complicated set of coordination mechanisms than just price, exit and buffers" (Grandori 2000, chapter 3, p. 7), Grandori insists that we should term this coordination *price*-coordination and not *market*-coordination (Grandori 1997, p. 34).

¹² Grandori uses the term "codified" for capturing what type of information is needed before it can be transferred by price coordination. However, it seems to me that the two major preconditions for information in a price system are that information is (a) easily transferred and (b) easily understood in the same way by local decision makers. It is questionable whether the fulfilment of these requirements equals that information is codified.

¹³ Without denying that voting can be of importance even in economic relations, in the following discussion I will mainly focus on price-coordination; an area in which organisational economics has most to offer.

alternative, using a mixture of incentives (as in the cases of price and vote coordination) and of monitoring mechanisms (as in the case of authority). In the case of agency coordination, parts of the decision rights (and often also of risks) are transferred to the subordinates. Both authority and agency require information transfer between the principal and the subordinates. The principal transmits information to subordinates in the guise of more specific (the case of authority) or less specific (the case of agency) instructions. Subsequently, monitoring provides the principal with information on the behaviour of subordinates (which is then used for providing incentives, designing new instructions, etc).

- Coordination in *teams* and by *negotiation*. In *team* coordination, information is transferred without any hierarchy among a group of agents. Decisions are made jointly and unanimously, and consequently decision rights are equally shared. Closely related is *negotiation*, which is also based on reciprocal information sharing, but where conflicting issues are paid more attention. Negotiation processes lead to joint, but not necessarily unanimous, decisions.¹⁴
- Coordination through *institutionalisation of norms and rules*. Rather than pertaining to calculations of interests and processing of information, actions are based on knowledge that is common within a given context, i.e. the knowledge included in (social) norms (including routines) or (formal) rules (including procedures). This allows agents to coordinate their actions by first coordinating their beliefs (expectations, plans, strategies, etc.). Using such institutionalised “signposts”, decisions are made unilaterally. Hence, these coordination mechanisms do not primarily serve to coordinate the actions of agents with different information and interests. Rather, they align the very information and interests.

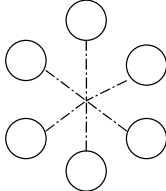
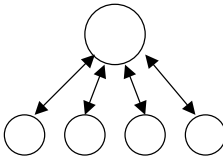
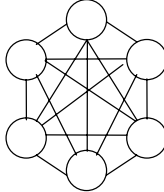
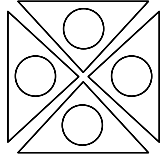
As seen, these 2x4 coordination mechanisms represent different types of information transfer and use of knowledge. They span from a limited transfer of information in the cases of price and voting; hierarchical dissemination of information in the cases of authority and agency; local

¹⁴ The difference between teaming and negotiation is that conflicts/different interests are supposed to be dominant in the latter. Since I have paid less attention to incentive problems, I will not consider coordination by negotiation in the sections that follows.

sharing of information within teams and negotiations; and in the case of norms and routines, only a limited information transfer due to the prevalence of shared knowledge.

The different types of coordination and their properties with respect to information and knowledge are summarised in Figure 1.

Figure 1: Information and knowledge properties of coordination modes according to Grandori 2000

	Price & Voting	Authority & Agency	Teams & Negotiations	Norms & Rules
				
Decisions	Unilateral	Centralised (partly)	Joint	Unilateral & non-calculative
Information	Decentralised & codified	Centralised & partly codified	Decentralised & uncodified	Decentralised & partly codified
Knowledge	Local	Management	Group	Common
Communi- cation	One-way	Bilateral	Multilateral	No communication

Source: Grandori 2000, part II, p. 8.

As the figure visualises, the different coordination modes can be conceived of as different *information structures* (or *networks*), that is a set of nodes combined in different ways. In the perspective taken in this thesis, a node would represent a person performing an activity and the links represent transfer of information. Grandori (2000) hints at this approach, as she refers to authority as a partially connected network and teaming as a totally connected network. Yet she does not make information structures the main lead in her comparative assessment of coordination modes. As I will return to in appendix B, an "information structure" approach appears to be a promising way of grasping informational characteristics of coordination modes.

3.2. The choice of alternative coordination modes in a non-repetitive setting

3.2.1. Introduction: costs of identifying, creating and using coordination modes

Common to the approaches and typologies considered in the above is that all coordination modes are expected to have advantages and disadvantages. Thus, in general it seems that the use of coordination is a comparative assessment excised with the specific nature of the coordination job in mind. In more economic terms “advantages and disadvantages” can be perceived of as different *costs*. I propose that these costs can relate to different phases of the process of coordination:

- I. The cost of *identifying* the appropriate coordination mode. To recall, the appropriate coordination mode is expected to depend on a number of contingencies. Among other things, the costs of identifying coordination modes relate to the information costs induced by determining the exact nature and level of the contingencies.
- II. The cost of *creating* coordination modes. Coordination modes often depend on some sort of “infrastructure” to work efficiently. For instance, price coordination works through codified information (Grandori 2000) and thus, without an initial coding of information, it would usually be a very difficult coordination mode to use. In addition, there may also be *implementation* costs for a single firm or individual even when this infrastructure is in place, because the exact nature of the “infrastructure” has to be learned (think for instance of the costs associated with going from the US to the metric system).
- III. The cost of *using* coordination modes. One element of user costs is the information costs involved directly in the process of coordination, for instance the cost of obtaining, transferring and calculating information. Another element concerns the outcome of this information treatment: how well are activities coordinated,

that is to say how much are the actions of each party in agreement with the activities of other parties.¹⁵

Rather than addressing these costs of alternative coordination modes on a general level, I will try to direct the following discussion towards the specific setting addressed in this thesis: coordination of construction activities. Hence, let me briefly consider how construction activities are likely to look like when assessed according to the contingency view on interdependencies (see “The contingency view on coordination” above).

As mentioned (and as further elaborated on in chapter 5) this thesis is devoted to understanding coordination practices in situations of *low repetitiveness*, that is activities with a high *variability*. Hence, the impact of low repetitiveness on the cost of selecting, creating, and using different coordination modes is the first issue considered in the following sections.

In construction, two informational features go together with – and, as argued in chapter 2, are probably caused by – low degrees of repetition. The first is *exchange and processing of “heavy” information*. Since in- and output, as well as working procedures to a smaller degree, are standardised in one-off relations, a substantial amount of (quantitative and qualitative) information collection and processing is needed to perform an activity (Galbraith 1973, p. 5). This feature equals high levels of *activity difficulty* because in- and output and in turn also working procedures do not follow any recurrent and well known practices or procedures, but have to be assessed for every single operation (Van de Ven and Delbecq 1974, Van de Ven *et al* 1976).

Secondly, the *numbers of actors* (identical to “*size of work unit*”, Van de Ven *et al* 1976) that have to be considered in the act of coordination are, other things being equal, high for non-repetitive interactions. Due to activity complexity, variations and delays in input can easily accumulate along the value chain, thereby creating interdependence between remote parts of the value chain. And for novel or frequently changing activities, interdependencies are to a lesser degree known *ex ante*, and

¹⁵ In addition to these variable costs, there are also potential costs of maintaining the infrastructure needed for the respective coordination modes. For matters of simplicity *maintenance costs* are ignored in the following discussion.

consequently, many *potential* interactions have to be considered (K. Foss 2001b).

Thus, the analytical scheme for this subsection is to discuss the costs of (I) identifying, (II) selecting and (III) using alternative modes of coordination for activities that are (a) highly variable, (b) complex, and where (c) numerous actors are included. This discussion will mainly consider different theoretical contributions relating to different parts of this 3x3 matrix. As the literature on information costs on coordination is limited, rather than considering only narrowly defined schools, I have found an eclectic approach useful. With respect to coordination modes, the terminology used by Grandori is the main thread in the following discussion.¹⁶

The costs of in particular using, but to some degree also the costs of creating, coordination modes have been given most attention in existing literature on coordination. As these two costs are often treated as closely related (usually no distinction is made), I treat these contributions under the first heading ("The costs of creating and using coordination modes in a non-repetitive setting") in the following. The discussion is summarised by pointing out how the different theoretical claims can be understood by perceiving coordination modes as different information structures. However, the costs of identifying the appropriate coordination mode or modes appear to be a somewhat neglected issue in existing literature. In a repetitive setting this may be acceptable, but as I show in the second section from now ("The cost of identifying cost-effective coordination modes"), taking these costs on board in a non-repetitive setting seriously changes the expected relation between contingencies and coordination practices.

¹⁶ Grandori's own way to go about the advantages and disadvantages of coordination modes is by locating their *failure mechanisms*. A failure mechanism is a condition that, if met, makes a coordination mode inapplicable (Grandori 1997, pp. 29-33). However, as an analytical tool, failure mechanisms only describe the extreme positions where a coordination mode cannot be used. In order to get a more full description of which coordination mode to use when, I prefer to think of costs in order also to include less dramatic drawbacks, as well as the advantages of the different modes of coordination.

3.2.2. The costs of creating and using coordination modes

Coordination modes and low degree of repetition

Although all coordination modes include some infrastructure to work, the cost of creation (as well as using) differs from one mode to another. This in turn results in different impacts from the degree of repetition. Presumably *norms, rules, prices, and, to some extent, authority* are most significantly made more costly to use in situations of discontinuity.

Rules and norms guide behaviour in a non-calculative fashion and thereby reduce information costs on search and calculation (March and Simon 1958, chapter 6, Galbraith 1973, p. 10). They can be the result of a calculated design and implementation or the result of a learning process transforming past experience into guidelines for behaviour. In case of the former some level of repetition is necessary to carry the initial costs of inventing and implementing standards. In case of the latter, without repetition, there is no experience to learn from. Further, the unreflected “advice” from norms and rules would most likely be ill suited for problems that are not identical. Consequently, it is hard to imagine norms and rules without decisions that are repeated approximately in the same way for long periods of time (Grandori 1997, pp. 37-38) and their effectiveness is conditioned to repetitive and stable activities (Grandori 2000, chapter 7, p. 7).

As Thompson (1967) defines standards as “the establishment of routines or rules”, the cost of creating and using standards in a non-repetitive setting is closely related to the identical costs of norms and rules. Standards involve set-up costs and often work by being “reusable pieces of knowledge” (Langlois 1999). Consequently, they do not only enhance (March and Simon 1958, p. 181) but also depend on stable and repetitive activities. Thus, low repetitiveness limits the use of a range of different kinds of standards: standards on material, standards on language (ibid. p. 184), including coding of communication (Crémer 2000), or standards for tools and working procedures (Mintzberg 1979), including the provision of dies (Langlois 1999), standards on output or standards on skills (Mintzberg 1979).

Even though these different types of standards are all associated with some level of recurrence, they are not identical in this matter. Mintzberg (1979) suggest that standardisation of work, outputs and skills is used for

increasing levels of complexity, respectively. Although Mintzberg is not very explicit on the concept of complexity, it is at least partly related to the degree to which activities are routine (*ibid.*), i.e. repeated.¹⁷ In a similar way, Galbraith (1973) argues that as activity uncertainty increases beyond the capacity of hierarchy, centralised programming of work processes will be replaced with decentralised decision-making by a professionally trained workforce working with “craft principles” (as also discussed in chapter 2).

Prices are based on a particular form of standardisation: the provision of a market-wide code. It is this coding that allows information to be transferred and understood in identical ways by a wide range of actors making up and, in a similarly codified way, reporting back their decision. As the cost of codification in part is an irreversible investment - not only for the “creator” of the code, but also for the one who would like to acquire an existing code - (Arrow 1974) the profitability of this type of coordination depends on some degree of repetitiveness (Cr  mer 2000). Codification of information takes time. Thus, when coordination concerns new kinds of information, coordination by prices is usually not a swift mode. On the other hand, if information is codified, coordination by this principle can be quick indeed (as witnessed on, for instance, the stock exchange).

As pointed out by Coase (1937), the meaning of coordination by authority (“direction”) is to allow for the use of more flexible contracts when forecasting is difficult. Hence, a core feature of authority and the firm is its ability to adjust to changing or truly new situations. The latter aspect is stressed by K. Foss (2001b), who explains the existence of the firm by its, compared with the market, low costs of experimenting with new coordination problems stemming from an increased division of labour. According to this view, it seems that, compared with price based coordination, authority is generally better at handling coordination of activities where forecasting is difficult, for instance, due to limited repetitiveness.

¹⁷ According to Mintzberg (*ibid.*), complexity also refers to the size of the group.

The exertion of authority is often defined by, or at least associated with, the establishment of the firm (Coase 1937, N. Foss 2000a).¹⁸ As authority implies that a sub-ordinate places his working capacity at the disposal of a superior, an employment contract has to be specified. In this way, there are set-up costs to the firm and thus “continuity of operations is one of the hallmarks of the firm” (Casson 1997, p. 79). Without repetition of this kind, it may not be worthwhile for individuals to transfer the responsibility for decisions to a firm (*ibid.*).

Consequently, in situations where decisions are expected to be repeated only for a limited period, a temporary delegation of decision rights to superiors can be in the interest of individuals. In case some decisions are repeated for long periods and others for shorter periods, a way to reduce on the overall number of contracts is to employ people working with the longer-term decisions within the firm. The rights relating to the shorter-term decisions can then temporarily be transferred to another firm. In this way, quasi-integration, or subcontracting, can be alternatives to firm integration (Aoki 1986).

The level of repetition will not only affect the extent, but also the character of authority. As Penrose (1959) makes clear (in her discussion on why and along which lines firms grow), when an operation is launched for the first time, management will be devoted to planning and guiding this operation. However, as time passes, additional experience is gained, thus releasing resources, which can be directed towards new activities (*ibid.* pp. 537-538). Hence, in the beginning of an operation, managers will presumably work with activities in a conscious and time consuming way that is gradually reduced as the operation continues.

A third implication of repetition with regard to authority goes back to the fact that low repetition is likely to result in the establishment of “clusters of identical knowledge” (like trades) (see chapter 2). If employees within a firm have the same educational background, it would be expected that the person directing these people would be of

¹⁸ As N. Foss (2000a) favours a property rights approach (in which authority indirectly is acquired through ownership), he disagrees with the point of view taken, for instance, by Grandori (2000), that there or no clear relation between boundaries of the firm and boundaries of coordination modes. Correspondingly, Grandori (1997, p. 35) disagrees with the fundamental assumption that there is a clear relation between authority and ownership.

the same profession, since it is “easier to communicate with other individuals with whom one has a common approach or a common language” (Arrow 1974, p. 42).¹⁹

However, there might be situations in which activities are so different from one point of time to the next, that the costs of creating a firm are not feasible. In this situation, it may be favourable to coordinate activities by teaming. As decisions are taken unanimously (any person can veto a decision), no initial contract specifying the rights and duties of each party has to be formed. Thus, for highly variable activities (i.e. activities with low repetitiveness “in and across time”), teaming appears to be a better-suited coordination mode. Yet, in order fully to understand the relation between low repetitiveness and the (widespread) use of teaming, the impact of low repetitiveness on the number of actors and in particular the complexity of activities – as discussed in the two sections that follows – must also be considered.

In balance, it seems that teaming and negotiation is most apt for handling variability in activities, then follows authority and agency, then pricing and voting whereas norms and rules requires the most stable environment to work efficiently.

Coordination with many actors

As the number of actors involved in a process of coordination increases, so does the amount of information transferred and assessed in the system. However, due to different designs for handling information, coordination costs as a function of size differ in, at least, two separate, and often opposed, aspects: (I) the total information handled within the system (i.e. the sum of information costs carried by each individual in the system); (II) the maximum information load put on one or more central actors. As the capacity of the individual to obtain and process information is limited (Arrow 1974, p. 37 and p. 39), information bottlenecks – for instance resulting in delayed or inferior solutions (K. Foss 2001, p. 7) – is a potential drawback from exceeding this capacity.

¹⁹ If it is assumed that the benefits from specialisation are positively correlated with the difficulty of performing an activity, it should also be expected that as homogeneity decreases, the difficulties of monitoring and instructing people, managers in homogenous firms will to a lesser degree than managers in more heterogeneous firms possess specialised managerial capabilities.

Teams and negations is probably the type of coordination mode that suffers the most from increased group size. As they represent totally connected networks, the total number of relations increases dramatically when a new person enters.²⁰ Thus, team coordination is usually not considered to be efficient for large groups (Grandori 2000, chapter 5, p. 12).

A way to reduce overall communication costs in large groups is to establish a network that is only partially connected (Grandori 2000, chapter 4, p. 1), for instance, centralised networks. Centralisation can reduce the number of communication ties and by this minimise duplicate (Arrow 1974) or irrelevant (Casson and Wadeson 1999) information. In particular (and as discussed in chapter 2), it is efficient when information is decisive (Casson 1994).

Hierarchies, in which persons are given authority to direct actions of subordinates, are one example of such more centralised designs (Balton and Dewatripont 1994). As communication is bilateral (as it is between a subordinate and a superior), the sum of relations as a result of group size, in most cases and roughly speaking, only increases with a factor two. However, since information is concentrated at superiors, the risk of information overload and subsequent errors rises (Arrow 1974, p. 74) with increasing size. A progressive decentralisation of authority is therefore likely to go together with size (Penrose 1959, p. 566).

In principle, bottleneck problems in hierarchies can be solved by creating sub-hierarchies, where the size of each hierarchy does not exceed the number of actors possible to handle by a single superior. However, this solution relies on the premise that the knowledge required for coordination at the next higher level need not descend into the lower levels of the scale. This is not always possible due to the fact that “the knowledge of the particular circumstances of time and place” (Hayek 1945, p. 80) “in almost every instance [makes] knowledge of the detail of a problem ... an essential condition of its solution” (Robinson 1934, p. 254). Furthermore, many sub-ordinate levels - or to term it differently, a big span of control - makes decision-making a lengthy matter not suited

²⁰ The number of relations in a totally connected network is $n*(n-1)/2$ (where n is the number of members in a team). For example, in a team with two members there is one relation, with four members there are six relations and with 8 members there are 28 relations.

for urgent decisions. Another implication of a big span of control is the danger that information is lost due to noise (Marschak and Radner, 1972) when decisions are pushed up and down many hierarchical layers.

A partial delegation of decision rights, as in agency, is another way to reduce, but not avoid, information bottlenecks and large spans of control.

Decisions based on votes or price-bids are unilateral: the individual only needs to pay attention to his own needs and can disregard the wider effects of his actions (Arrow 1974). As a result, the overall communication costs do not expand dramatically, when a new actor enters – only the actor that enters needs to obtain and calculate information. At the same time, information bottlenecks do not rise, since information is not centralised at any single agent, but is possessed and used by the “man on the spot” (Hayek 1945. p. 83). In this sense, it is a highly efficient way “for coordination of large systems of comparable actors through structured quantified information available to everybody and without further communication” (Grandori 1997, p. 33) than the one conveyed in prices (Shearmur 1994, p. 191). On the other hand, due to the aforementioned set-up cost of codification, it is usually costly to use for a limited number of transactions and thus, other things being equal, costly to use in small groups.

The same conclusion pertains to social norms and rules that also work through local decision-making (but with the use of common and not individual knowledge). As calculative decisions often are replaced by learning from past decisions and experimentation, the individual costs of using this network, given that norms and rules are in place, is very low.

In balance, these reflections suggest that, other things being equal, the cost of coordination when groups expand in size increases most rapidly for coordination by teaming; then for authority and to a milder degree agency; whereas coordination by price, and in particular norms and rules, are the most efficient ways to economize on information costs in large groups.

Coordination with activity complexity

To recall, activity complexity refers to the degree of complexity of the search process in performing the activity and the amount of thinking

time involved in processing information. In general, teaming is believed to be efficient for high degrees of activity complexity:

“A team can realize significant cognitive advantages over other mechanisms in dealing with complex problems. Rather than working to reduce the quantity of information processed and exchanges, as pricing, voting, authority and agency do in different ways, a team’s distinctive way of dealing with uncertainty and knowledge complexity is to amplify the capacity for processing information, the cognitive power of the decision systems.” (Grandori 2000, chapter 5, p. 4).

Consequently, as activity complexity increases, coordination by for instance standards or authority is expected to be replaced with direct lateral contact among “subordinates” (Ito and Peterson, 1986).

The problem of using authority for high levels of activity complexity goes back to the aforementioned bottleneck problem. The central agents’ limited capability for handling information involved in instruction and monitoring makes it important, that activities are of a rather homogeneous or structured nature concerning their information requirements (Grandori 1997, p. 35, Grandori 2000, chapter 4, p. 6)). Agency - as a less centralized model - is able to manage higher degrees of activity complexity. But as the set of possible actions taken by agents should be clearly defined (Ibid. p. 36), there are limits to the span of different activities coordinated by agency due to, among others, “ink-costs”.

When activity complexity is high, a great deal of (different) information needs to be codified prior to the use of pricing, which makes coordination by this principle rather costly. These costs pertain to the costs directly involved in codification, as well as to the information often lost in this process due to “sticky” information (Hippel 1990b).

However, teaming is not the only way to handle high levels of activity complexity. In repeated interactions, it is possible to save enormous amounts of cognitive effort - and thereby freeing attention and cognitive resources for new areas of action - by norms and rules based on experience rather than calculative decisions. As a significant part of information collection and processing can be built into norms and rules, they have the potential of coping with still higher levels of activity complexity. This is particularly true for social norms. Unlike formal rules

they do not depend on whether a complicated coordination problem can be translated into codified descriptions or procedures. Consequently, even though norms and rules often appear to solve trivial coordination problems (as Thompson 1967 suggest), *ex ante* institutionalisation of these problems can be very complex indeed (Grandori 2000).

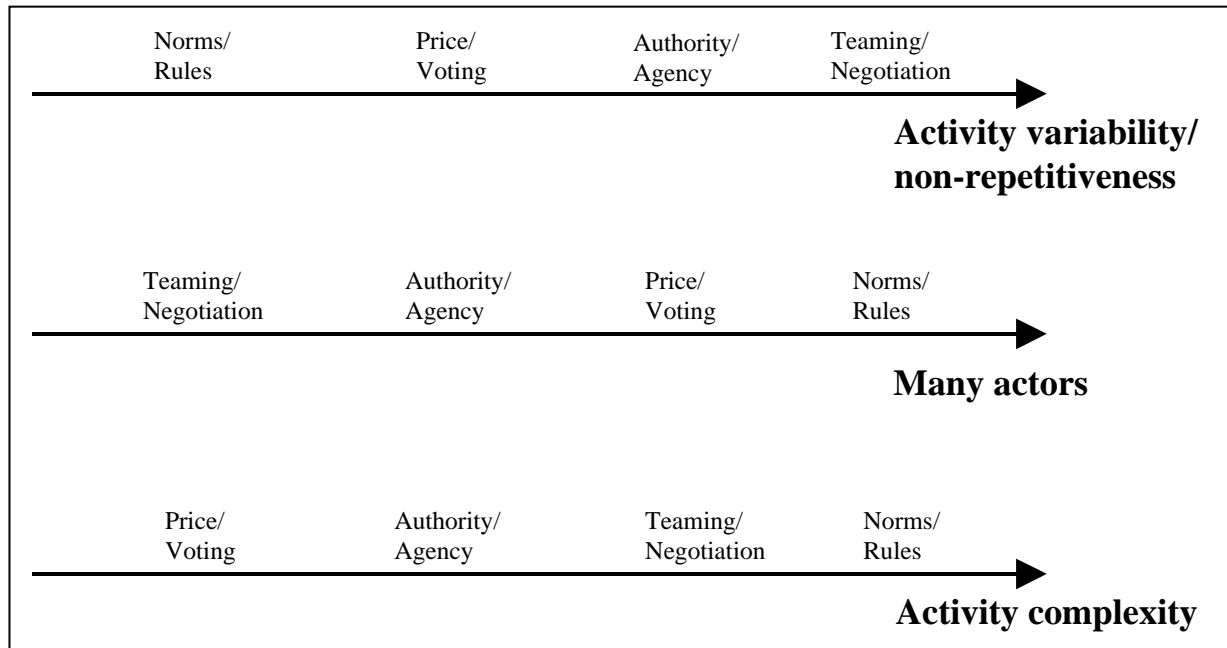
Summary: Coordination of non-repeated complex activities with many actors involved

In the above, I have discussed the use of different coordination modes in a set-up that is likely to be prevalent for non-repeated activities. Besides low degrees of repetition (high activity variability), this is - as argued in this chapter and chapter 2 - complex activities with many actors involved. The main argument developed throughout this discussion is how costs of creating and using alternative coordination modes differ according to these three information-related dimensions.

The discussion presented here suggests that the different information aspects of coordination and the different costs of coordination interact in a complex way. Firstly, the costs of using a coordination mode depends on the initial investment made in this mode. Secondly there is an interplay between the three contingencies. For instance, if activity variability is high, it becomes less profitable to reduce the complexity of an activity by, say, norms and rules.

Nevertheless, the assessment of a range of literature pertaining to information costs of coordination has given credence to the proposition, that each of the four pairs of coordination modes outlined by Grandori has specific properties with respect to the three informational contingencies. Figure 2 recapitulates, in a very rough way *and other things being equal*, this discussion by indicating the ranking of the different coordination modes along these variables. As the position of each coordination mode indicates its *maximum* ability to handle information, supposedly multiple coordination modes can be found towards the left-hand side of the variables (that is with low information requirements for that particular variable).

Figure 2: A rough ranking of the expected ability of coordination modes to cope with three information-related variables



Explanation: The more to the right a coordination mode is placed, the higher the level of the relevant variable this coordination mode can cope with. As the figure only proposes a ranking, it is only the order and not the exact position of each coordination modes that matters.

The existence of multiple equally efficient combinations of coordination modes

If the dimensions and rankings proposed in Figure 2 are put together in a three-dimensional space, it appears that it is difficult to advise a coordination mode for a combination of non-repetitiveness, many actors, and complex activities. For instance, norms and rules would be effective with respect to many actors and a high degree of activity complexity, but is poorly suited for the low level of repetitiveness. Teams and negotiations are efficient with respect to coordination of non-repeated complex activities, but are difficult to use with many actors. Alternatively, authority and agency, which take a medium position on all three variables, could be used.

Thus, the inclusion of more than one variable on which the cost of using coordination depends, does not only makes the analysis (of which coordination mode to use when) more complicated. It also creates the risk that activities are placed in a part of the n-dimensional room (of

which I have only considered three dimensions) in which there is no obvious coordination mode to use:

“Some combinations of these [failure] mechanisms are easier to handle – that is they are compatible with a wider set of mechanisms – eventually all...Other combinations are very difficult to govern, the set of feasible solutions shrinks – eventually to a void set. (Grandori, Conclusion, part II, p. 2):

Therefore, unlike Thompson (1967), choosing a coordination mode is not only a question of identifying the kind of interdependence and then apply the appropriate mode. There may be a trade-off between coordination of different variables. For instance, the complexity of how to carry out an activity may be ignored deliberately in order to allow for interaction of more parties. As there is not always a single superior way to coordinate a given set of activities, multiple equally efficient combinations of coordination modes can exist.

3.2.3. The cost of identifying cost-effective coordination modes

So far, we have been concerned with the cost of creating and using coordination modes. The underlying assumption has been that by adjusting activities and coordination modes to each other, coordination costs can be minimised. However, one aspect of coordination has not been dealt with yet: the cost of *identifying* such a fit.

For instance, if we for moment consider the activities as given, coordination modes should be selected according to contingencies of the activities subject to coordination. To collect and process information about these contingencies is an investment that has to be traded off with improvements in coordination. In a repetitive setting, such initial costs can be issued to several interactions, or they can be substituted with learning from past experience. But as we move towards one-off interactions (as this theoretical part has in focus), costs of identifying effective coordination modes should be taken more and more seriously.

Thus, in a non-repetitive setting, it would usually not be profitable to fine-tune activities and coordination modes to each other. Rather, a coordination mode, or combination hereof, that roughly fits most activities would probably be recommendable. Hence, we would expect that in coordination of systems with low recurrence of identical activities or identical sequences of activities, coordination patterns are relatively

robust to differences in contingencies, and therefore distant from the predictions of the theories on coordination modes discussed previously. And conversely, in coordination of recurrent activities, patterns of coordination modes are relatively differentiated and closer to theoretical predictions.

The robust coordination pattern applied in situations of low repetition would ideally be designed in such a way, that it *on average* is closest to the coordination modes encouraged by the different contingencies (e.g. number of actors, and activity complexity). The exact position of this average could ideally be estimated by an ongoing trial and error process which also allows for encompassing changes over time in the activities subject to coordination. However, once investments in particular ways of structuring and transmitting information have been made, it will be cheaper to use these, rather than to establish new – and in itself better – ones (Arrow 1974, p. 41). Due to this initial and partially irreversible investment in coordination modes, patterns of coordination modes are likely to be stable not only for a range of different activities at any given point of time, but also over time.

SUMMARY ON THEORETICAL PART

Chapter 2 and three have provided a theoretical framework by which we can address the research question on why specific forms of coordination are used during the process of construction. Chapter 2 provided theoretical explanations to *why* coordination is needed and *by whom* it is done. Chapter 3 dealt with the issue of *how* to coordinate.

Chapter 2 emphasises *repetition* as essential to coordination. *Repetition in activities* encourages a *division of labour* (and hence creates growth); a division of labour, which creates a *division of knowledge* and hence necessitates coordination. Repetition of the single activity can be promoted by well-known and identical in- and output made feasible due to *repetition in sequences of activities*. However, a system, where all activities are fixed to each other, is not very *adaptable* towards change in external conditions such as, say, (quantitative or qualitative) variations in the demands of customers. Hence, some relations between activities are organised on a more temporary basis. These temporary and varying relations constitute a threat to repetition of activities; in particular when products do not have a general use and hence cannot easily be coordinated by markets (and as argued, the degree to which products are standardised/have a general use is also expected to be dependent on, or at the least promoted by, some initial level of repetition in specific relations).

However, the existence of people specialised in handling these variations allows for a division of labour even when external changes exists: one group of people works repetitively with adaptation to changes (*specialists in coordination*); another group works repetitively with performing specific activities (*specialists in production*). As argued, it is likely that a structure in which the former group of specialists instructs the latter group, minimises on information costs. In this perspective, the firm is essentially a structure that enables specialisation in production through specialisation in coordination. The specific boundaries of the firm are drawn by these benefits of specialisation (i.e. of repetition) versus the benefits of being adaptable to external changes. Therefore, as external changes increase, shorter and shorter strings of repeated activities are handled within a firm (*unilateral coordination*) or directly between two firms (*bilateral coordination*). Since interactions between specific firms and

individuals are not repeated, coordination is potentially troubled by idiosyncrasies. The existence of the *trade organisation* (or *isomorphism*) is a way to replace repetition between specific firms and individuals with repetition between specific groups (i.e. trades). An important implication of (the benefits of) having a single organisational design, such as the trade organisation is that it potentially creates *path-dependency*. *Craft production* is another mean to reduce the interdependence of activities by using highly skilled workers, who buffer in- and output variations through local decisions.

Finally, a high level of change in external conditions, e.g. changes in overall demand, is likely to increase the limitations of both markets and firms. Hence, it is argued that the existence of interfirm coordination beyond simple market coordination is likely to be especially dominant in non-repetitive settings. *Bilateral coordination* directly between two firms is one type of inter-firm coordination. However, interfirm coordination mediated by a third firm specialised in coordination (*trilateral coordination*) is another (and theoretically less explored) option. The line of argument in chapter 2 proposes, that the higher the level of external change, the more interfirm coordination will move from being bilateral to trilateral.

Chapter 3 analyses the cost of handling information through different modes of coordination in a setting of unrepeated production.

The information-based (or at least information *biased*) literature on coordination has been reviewed in order to identify different modes of coordinating activities. Then theoretical contributions that further an understanding of the cost of handling information by these different modes have been considered. Particular emphasis has been given to contingencies that are likely to follow from low repetition. Besides (a) low repetition (/high variability) in activities, this is (b) complex activities with (c) many persons potentially involved. The costs of handling these contingencies through different coordination modes have been discussed along three different dimensions of information costs: the cost of *identifying* which mode to use, the cost of *creating* coordination modes, and the cost of *using* coordination modes.

With respect to the costs of creating and using coordination modes, it is argued that discontinuity is likely to impose significant costs of using coordination by *prices*, *norms* and *rules* and thereby excludes

coordination modes that are considered very cost efficient in repetitive settings. This brings coordination by *authority*, *agency*, and *teaming* to the fore. However, these coordination modes face limitations with respect to handling the extensive information and involvement of many actors. Thus, it is proposed that is very difficult to find coordination modes which nicely suit the combination of coordination objectives likely to arise in non-repetitive situations. Consequently, the selection of coordination modes for specific activities is not necessarily a matter of choosing a superior solution to an inferior one (as Thompson suggest), but can be a matter of choosing between two or more equally “poor” alternatives.

In contrast to the reviewed literature, it has been argued, that in order to understand the efficient application of alternative coordination modes, costs of *identifying* coordination modes has to be added to the cost of *using* and *creating* different coordination modes. For recurrent sets of activities, these identification costs may be negligible since they are written off on many activities. But the lower the degree of repetition, they more important they become. Consequently, in coordination of systems with low recurrence of identical activities, coordination patterns are expected to be relatively robust to differences in contingencies, and hence often distant from the theoretical predictions following from considering only costs of using and creating coordination modes. Conversely, in coordination of repeated sequences of activities, coordination modes are expected to be relatively differentiated and close to theoretical predictions – i.e. the same coordination mode is used for activities with the same kind of contingencies, and different coordination modes are used for activities with different kinds of contingencies.

Chapter 4 - On Method

4.1. Introduction

In this chapter I describe the choices and reflections on method governing the empirical analyses presented in chapter 5 and 6.

I start out by explaining why a *case study* - in combination with statistical inquiries - is chosen as the main source to empirical data (section 4.2). The remainder of the chapter is devoted to analysing and discussing consequences of this choice. Section 4.3 relates to the possibility of making *generalisations* primarily from a single case study. In section 4.4 it is discussed, how different empirical sources enhance the *construct validity* of the case study. Section 4.5 explicates why *the particular case* on roof construction in a multiunit residential house was selected and some consequences hereof with respect to generalisation. The section (4.6) on *reliability* concerns the questionnaire and operationalisation of main concepts used for collection of data. The final section (4.7) discusses the strategies used for *analysing data* taking the explanatory AND explorative elements of the present case study into account.

4.2. Why a case study

Numerous research strategies can be used for data collection: experiments, archival analyses, histories, surveys, case studies etc. (Andersen 1997 and Yin 1989, p.p. 15-20).

Choosing a strategy (or combination hereof) is not easy because as observed by Turin 1966 (p. 8):

“Studies of the building process have to steer a difficult course between the Scylla of intensive and necessarily expensive inquiries of isolated examples, and the Charybdis of more superficial studies of a large number of objects examined under few headings only, but having some statistical significance. It is easy to say that both approaches are complementary; it is considerably more difficult to make them so...”

This thesis combines statistical data with an in-depth case study. Hopefully this will make it possible to find a safe course between Scylla and Charybdis.

In chapter 5 the data provided by public registers and summarised in the so-called IDA-database will be used (this may be conceived off as archival analyses by statistical means). A benefit of this data source is that it gives information on a wide range of objects (in fact all persons, working places and firms in Denmark). Besides allowing for broad sector and cross-sector inquiries, it makes it possible to study economic organisation at different aggregation levels: the national levels, the industry level, the firm level and the level of individuals. So even though it does not provide us with direct data on the project level, to some degree it makes it feasible to link the macro (systemic) level with the micro (actor) level, rather than simply having both the dependent and independent variable at either the macro or the micro level (Coleman and Hao 1989). In addition, it allows for longitudinal studies on, for instance, survival rates. Finally, by using an existing database, resources are saved on collecting data.

However, the latter is also a limitation to this data source. As the IDA-database is based on public registers and designed for research in the labour market, obviously it only provides indirect and limited data relating to the research questions of this thesis. As illustrated in chapter 5, some indirect indications on the division of labour (research question A) and the role of the firm as a coordinator (research question B) could be given, but among other things, we learn nothing about how coordination is organised and practised on site.

For this and the following reasons I have found it most appropriate mainly to examine the research questions of this thesis by means of a *single case study*.

According to Yin (1989), the choice of a research strategy depends on (a) the type of research question posed, (b) the extent of control an investigator has over actual behavioural events, and (c) the degree of focus on contemporary as opposed to historical events. More precisely (ibid. p. 20) a case study research strategy is perceived to be advantageous when “a “how” or “why” question is being asked about a contemporary set of events, over which the investigator has little or no control”.

In many ways these three conditions fit to the situation of the present study. First of all, the overall research question is mainly of an *explanatory* nature (although it also contains *explorative* elements) as it aims at understanding *why* certain modes of coordination are selected for coordinating the activities involved in the process of house construction. The general idea being, that in depth studies, like case studies, are better at identifying causes than more distant methods, like *surveys*; the latter relating more to *prevalence* of phenomena (how widespread phenomena are) (Yin 1989).

A second characteristic of the object studied in this thesis, is that it represents a complex and only partly understood interaction between numerous parties. Thus, it is very difficult to study coordination *practices* by controlled *experiments* of any kind. An argument that is further strengthened by the fact that it would be very costly to use research designs, where people at the site are hindered from performing their daily business. This is particularly true for the craftsmen who are paid by the piece, and hence the only option is to interview them, when they have some spare time between some of their operations. An alternative would be to restrict the interviews to people at the higher level of the organisation who are not governed by the payment by the scheme contract. But this will leave out the potentially important part of coordination taking place directly between the craftsmen and would seriously limit the relevance of the study. Furthermore, the story of coordination would be very incomplete if only the “upper level” of the project organisation was examined – as witnessed on several occasions in the case study, the gap between what is planned and what actually takes place can be rather large.

Thirdly, I am studying contemporary events and hence have the option of using the various sources of evidence – like interviews and observation – that in combination are the unique strength of case studies (Yin 1989, p.p. 20-21). Hence, an advantage of the case study is that it provides a very detailed and embracing view on ongoing processes (Holme and Solvang 1986). This is important since I do not have any personal experience with construction activities on site - many of the activities performed by the craftsmen would mean little to me if only explained in words. In order to understand what is going on, observation on site was needed. On top of that, being a part of the

environment for a four-week period gave a brilliant opportunity for informal discussions and observations on issues, that I would not have known to ask for in advance. In order to reap the full benefits of this, I followed the same working hours of the craftsmen (7.00-15.00) and participated as often as possible in the breaks at 9.00, 11.00 and 13.15 in the workmen's hut.

In the same vein, case studies are perceived to be beneficial in situations, where little is known about a phenomenon empirically, or when "freshness" in a theoretical perspective is needed for an already researched topic (Eisenhardt 1989). To recall the introduction (chapter one), both situations seem to apply to the present study. Firstly, organisational studies of construction processes are sparse and studies explicitly addressing these processes from a coordination point of view even more so. Secondly, even if the empirical field is extended beyond the construction process, most contemporary studies of coordination practises have taken an *incentive* based approach to coordination. Naturally, these studies only add limited insights to information-based theories on coordination.

With these characteristics in mind, it also becomes evident why a survey - for instance based on a large sample of questionnaires - for very practical reasons was not an option I considered at any length. Firstly, I would not know how to phrase the questions in a way comprehensible to people on the construction site. Secondly, the options for adjusting my questions on a, at least in the beginning, continuous basis would have been very limited. The limited empirical interaction would increase the risks that the concepts that I used did not capture the most important elements of the studied objects (as discussed later in the section on "construct validity"). Thirdly, the craftsmen would not bother to answer questions - especially not in a written format.

However, case studies are time consuming; especially when interviews can only be made, when craftsmen have some spare time. For the same reason it has only been attempted to conduct a *single* case study. This in turn raises the question of generalisation: how much can be said about other building projects based on this single case?

4.3. Generalisation from a (single) case study – external validity

Perhaps the most important lesson to take away from this chapter concerns the *external validity* of the case study; that is the degree to which the findings can be generalised beyond the very domain of the case study. In accordance with Yin (1989), the view taken here is that the possibility of generalising the empirical findings of a case study relates to theoretical propositions or claims (“analytical generalisation”), and not to populations (“statistical generalisation”). In this way the case study does not represent a “sample”, that (with some level of statistical uncertainty) is claimed to be valid for the organisation and structuring of coordination outside of construction.

Thus, I do not claim that I am able to say anything specific about the extent to which the observed coordination practices apply to other empirical settings. To the degree that there is any room for generalisations of an empirical nature, this goes through a theoretical framework and further empirical studies. The concepts and perhaps even the causalities identified in this case study can pave the way for a (revised) framework on the selection of coordination modes. This framework can then facilitate an analysis of the selection of coordination modes used for other economic activities; but the degree to which the framework actually represents a (more or less) “true” picture of how these activities are coordinated, cannot – not even by some measures of probability – be known in advance.

The degree to which generalisation of a statistical nature is possible, partly depends on how the case is selected. A *critical case* is a case in which a theoretical proposition is expected to be extremely likely to be confirmed (or not to be confirmed). By using such cases, it is possible to deduct that “if the theory is (not) valid even in this unfavourable (favourable) situation, it will apply to all (no) other cases” (Flyvbjerg 1992). However, a fundamental problem with this approach is, that it depends on *ex ante* knowledge about whether a case is critical or not. This requires some initial empirical knowledge on the causalities of the involved concepts, and hence excludes the use of critical cases in situations in which there is limited empirical knowledge; exactly the situations for which the case study is pointed out as a particularly useful research strategy (Eisenhardt 1989). Thus, this dissertation has not aimed at identifying a critical case which, beyond the level of analytical

generalisation, could explain the selection of coordination modes outside the empirical setting of construction.

Yet, in the section “*selecting the case*” (4.5) I will argue, that the activities studied as part of the case study on roof construction with some reservations is similar to a wider set of construction activities. And hence, that I have no reason to expect that they are fundamentally different from construction processes in other parts of a building project.

4.4. Construct validity

Construct validity relates to whether the concepts and measures applied for studying phenomena measure what they are intended to measure. Thus, internal validity concerns if the operational definitions (the ones used during fieldwork) correspond to the theoretical definitions. A lack of correspondence can have two outcomes. Too narrow an operationalisation of a theoretical concept will cause important phenomena to be overlooked; too wide an operationalisation, that irrelevant phenomena are included.

Using *multiple sources* is a way to increase the construct validity of a study. The study at hand has combined different sources in various ways: (a) combining quantitative and qualitative approaches, (b) prior knowledge of the parties and phases involved in building, (c) a test study on coordination practices, and (d) a combination of observation and interviews. In the following I consider these four different ways to increase the construct validity of the case study.

4.4.1. Combining quantitative and qualitative approaches

As mentioned in section 4.2, even though the main data source in this thesis is a single case study, statistical information provided by in particular the IDA-database has also been used. A primary objective of using this database was to show, how changes in overall demand propagates to the level of firms and individuals, which in turn is likely to favour certain ways of organising and executing coordination of the building process. However, the data also provided information, that is more directly related to the research questions.

In this way, it has been possible to substantiate some of the observations from the case study, for instance with respect to the existence of the trade organisation and craft production.

The presence of *cliques* is another example of using multiple sources by combining quantitative and qualitative data. During the case study I became aware of the fact that some of the carpenters move in cliques from one firm to another. This is potentially a very interesting observation, as it suggests, that repeated interaction and thus specialisation perhaps takes place even without repeated interaction between or within specific firms. And thus, it could be the case, that - in spite on the picture on building outlined in chapter 5 - there would be specialisation in building. However, the subsequent inquiries in the IDA-database did not support the view, that cliques are particularly widespread in construction compared with manufacturing.

4.4.2. Prior knowledge of the construction process - To get a “feeling” for the actors and phases involved

An important part of conducting empirical research on a topic on which there is only limited prior knowledge, is to get a “feeling” for the empirical field. First of all, without knowledge of the basic actors and processes, it is not only difficult to understand, for instance, the answers given by respondents; very often some minimal knowledge is required in order to gain access to and acceptance from the people working in the field. Secondly, a theory-informed approach to collecting data – as used during the case study of roof construction – seriously faces danger of merely reproducing theory, rather than grasping the essence of the empirical field (Eisenhardt 1989). This thesis has benefited from different sources of prior knowledge on the process of construction (see also table 1 in section 4.4.5)

To recall the remarks in the preface of this thesis, originally I was introduced to the “world of construction” while representing the client in a dozen building projects. Besides arousing my curiosity, this gave an introduction to some of the major parties involved in the building process; especially the client representatives, the design team (i.e. the firm of architects and the firm of engineers), the main contractor and the local authorities involved in the initial planning and tendering phases.

In commencing the PhD-programme, I participated in 10 site-meetings over 6 months in a social housing new build project placed in Farum, 20 km north of the centre of Copenhagen. The purpose of this was to get an idea about, what was going on at the building site. Later I decided not to use site meetings as a primary empirical source to coordination practices due to the specific status held by these meetings (see textbox on *The site meeting* in chapter 6). Nonetheless, these meetings gave an introduction to some of the superior (compared with the level of the craftsmen) organisational levels working on site.

Furthermore, I have been allocated part time to the Danish Building Research Institute, the Group for Productivity studies, during the PhD-programme. The people working here are relatively close to the daily practices of construction. I have benefited tremendously from being part of this environment, bridging practical and theoretical approaches to the organisation of the building process.

Finally, the mandatory work in the PhD-programme included three empirical reports (Thomassen 1998 and 1999, Clausen and Thomassen 2000) on the strategies for reorganising the building process pursued by the four Consortia involved in the PPB-programme (which this PhD-study is a part of). The contacts established in drawing up these reports turned out to be important in order to gain access to the empirical field, for instance the case study.

4.4.3. A test study conducted on the site

Departing from the theoretical speculations as presented in chapter 2 and 3, I developed a lengthy questionnaire addressing different aspects of the three research questions. Rather than using the questionnaire straight away, a test study (pilot case) was conducted on the site. In this case study, the organisation of coordination and the coordination modes used for instalments of windows were studied.

There were two major outcomes of this test study. Firstly, the theoretical concepts were turned into concepts, which were familiar to the people working on the building site. For instance, the theoretical concept of *authority* was translated into *instructions from foreman* or *instructions from project management*. Similarly, some constructs were deepened. For instance, rather than asking about how activities were dependent on each other, different dimensions of interdependencies were identified.

Secondly, the questionnaire was somewhat shortened as the interviews with the craftsmen usually were restricted to their short “natural” breaks. Some additional questions on innovation, that were “nice to know” but not “necessary to know”, were not pursued systematically. Similarly, the questionnaire was divided into some basic questions, which were asked for all activities and some additional questions, which were only asked, if the time and the conditions allowed for it.

How these different measures, partly triggered by the test study, were made operational is further explained in the section *The Questionnaire and operationalisation of main concepts* later in this chapter.

4.4.4. Data collection on site: combining interviews and observation

A third way used in order to increase construct validity was to combine the two main qualitative methods (Marshall and Rossman 1989): observation and interviews.

To recall, observation was almost inevitable since the only feasible way to get information at the level of craftsmen, was to stand next to them while they were working. By being present on the site, it became possible to understand the exact character of the activities performed during roof construction, which in turn enabled the interview with the craftsmen. As a further benefit of data collection through observation, the change of “getting surprised” (in the sense of becoming aware of aspects, which was not considered *ex ante* the fieldwork) is increased.

However, to rely solely on observation is a very time consuming affair and does not allow for observation of phenomena, that do not manifest themselves in any explicit form. Hence, interviews were used as a major source of data. The interviews were conducted by following a rather closed set of questions. This enables the collection of relevant and comparable data. A disadvantage of a (semi-)closed questionnaires is, that they do not favour more informal discussions in which crucial information often is revealed because the respondents can express themselves more freely. However, this kind of conversation took place during (often very lively) discussions at lunch and coffee breaks. Furthermore, the test study and previous experience with the construction process also reduced the risk, that the use of closed questions would miss important empirical insights.

The use of a questionnaire partly rooted in theoretical concepts – and partly adapted by initial findings in particular in the test study – also reflects a more fundamental stand of this dissertation. The purpose of this thesis *is not* to conduct studies inspired by a grounded theory approach. In this approach observations are (supposedly) interpreted with outmost care and with a limited theoretical interference in the outset. Even though this may provide more nuances than a more (deductive) theory-driven approach, it may also imply, that the theoretical point of departure is less pronounced, but not necessarily less influential. Furthermore, there is a balance to strike between on one hand making, theories “tractable” and, on the other hand, ensuring that theories to some degree “correspond to the real world” (Coase 1937, p. 386). The exact point of balance is of course difficult to locate and may also be a matter of personal opinion. If an inquiry is *truly* grounded (and does not only pretend to be so), in comparison with a more theory-driven approach, it will most likely get closer to “correspond to the real world”, but at the same time will probably also contribute less to “tractable” theories. Thus, the purpose of this study *is* to conduct empirical studies within the process of construction in order to see how this contributes to the theoretical field of organisational economics in general and theories on coordination in particular.

Coming back to more down-to-earth aspects of data collection, in most cases the respondents were treated as “ordinary” respondents, in the sense that they were only asked questions about their own behaviour. In a few cases however, they were interviewed as key informants (Marshall and Rossman 1989); that is, due to their experience, they were asked questions not concerning themselves directly (for instance “do you consider the problem described here to be typical for building projects in general?”).

Of course a central question is, whether the interviewed people are biased in any way: perhaps the interviewed people want to emphasise certain aspects of the story; think that they are expected to give certain answers; or give answers, that represent the common understanding of how things work etc. As an interviewer this is very difficult to control for due to asymmetric information. The questions on activities and coordination I was asking, did not appear to be very conflict-ridden (unlike issues like the working environment and salary, which the

craftsmen addressed unaided on several occasions). Furthermore, by combining observation and interviews, to some degree, it became possible to crosscheck for biases.

Finally, by studying a string of activities, I had information about both sides of the interdependencies reported between the activities. The relation between two activities is by no means symmetrical (*a* can be dependent on *b* without *b* being dependent on *a*), but having information on the relationship nevertheless facilitated an understanding of the answers given and allowed for crosschecking by asking additional questions.

4.4.5. Different data sources used as part of the case study

The different data sources that directly or indirectly enhance the construct validity of the present study are summarised in *Table 1*.

Table 1: The data sources used directly and indirectly in the case study

Location	Method used	Date	Duration	Persons/parties involved	Topics related to the case study
Chairman for a social housing organisation	<i>Participation</i>	1993-96	Represented the client in 12 building projects	Client , client representatives, architects, engineers, main contractor, public authorities	Basic understanding of the actors involved in the building process, in particular with respect to the initial <i>planning</i> and <i>tendering</i> phases.
Social housing project in Farum¹	<i>Observation at the site meetings</i>	1999	Participated in 10 site meetings	Client representative and three main contractors	Basic understanding of the actors involved in the building process, in particular with respect to the superior levels in the <i>execution</i> process.
Social housing project in Gentofte (the case study)	<i>Observation at project planning meetings</i>	2000-2001	Participated in 4 planning meetings	The firm of architects and the firm of engineers (the design team), the main contractor and client representative.	Basic understanding of the actors involved in the building process, in particular with respect to the more detailed parts of the <i>planning</i> phase.
Social	A test study on	2001	Approx. 20	The carpenters and the	Revising questionnaire

¹ The building project consisted of 67 + 33 (constructed in two phases) one-story row-houses.

housing project in Gentofte (the case study)	the instalments of windows combining <i>observation</i> and <i>interviews</i> .		hours on site	driver of the mobile crane.	and main concepts.
Social housing project in Gentofte (the case study)	The case study of roof construction combining <i>observation</i> and <i>interviews</i> .	2001	Approx. 100 hours on site	Interviews (using the questionnaire) with representatives of the seven trades directly involved in roof production. Interviews and informal discussion with project management and the architect about their role in the execution phase. Informal discussions with the craftsmen working on site, especially carpenters	Collecting information on the three research questions (see section on the questionnaire below).

4.5. Selecting the case

A building project can vary in multiple ways, for instance:

- The purpose of the building: is it a house, an office or an industrial building etc.
- The type of client: is it a private or publicly supported client.
- The size of the building.
- New build or refurbishment
- The exact period in which the construction project takes places.
- The geographical position of the building.

Based on prior knowledge, I had no reason to suspect that within the building part of the sector,² the organisation of this process would differ largely from one type of project to another.

² Whether this also is true for civil engineering projects (physical infrastructure such as roads, bridges, ports etc) is hard to say from the arguments that follow.

First of all, as a client, I had experienced more or less the same kind of problems on various projects even though they differed with respect to size and geographical position. Secondly, in the ongoing debate on how to organise construction in Denmark, the parties involved do not seem to consider that the perceived problems (and their remedies) were particularly profound in, for instance, social housing or that they have changed much over time. Thirdly, the construction firms in general do not appear to specialise in certain parts of the market, which indicates common organisational traits.

Of course these pieces of circumstantial evidence do not prove the uniformity of the organisation of construction projects (and thus the possibility of generalising from one building project to another). In order to check for this, additional questions to key informants on the specific project have to be asked (see the next section). Nevertheless, it reduce the criteria for selecting a case study to three main concerns.

Firstly, the case should be accessible, both in the sense, that it should be possible to gain access to the project, and in the sense, that it should be within geographical reach.

Secondly, this study intends to bring insights to the efficient application of coordination modes by studying the coordination practices used in the process of construction. However, the coordination practices observed in a single case study can be an efficient response to given contingencies, or a result of mismanagement. In order to ease the interpretation of data, it would be ideal, if the impact of management could be reduced (at least to the degree that the observed coordination practices are not a result of particularly bad management).

Naturally, it is difficult to identify best practise based on a single case study. However, tentative indications suggest, that the project at least do not represent “worst practice” with respect to how coordination is managed.

First of all, the case is part of the PPB-programme (as outlined in the introduction) as it is built by the PPU-consortium.³ At the building site

³ The PPU consortium is a one out of four consortium in the PPB-programme. The PPU consortium consists of MT Højgaard, Rambøll and Arkitektgruppen i Århus. MT Højgaard is the merger between Højgaard og Schultz and Monberg og Thorsen. Højgaard og Schultz is the original participant in the consortium.

level – studied in this dissertation – this seems to have very little impact since the constellation of people is as new as for any other building projects. At the planning level however, there is a higher degree of repetitiveness among the architect, engineers and main contractor, which provides better conditions for a well-planned project.⁴ Secondly, the carpenters are rather experienced. The two carpenters mainly assigned to roof-construction have more than 30 years of experience as carpenters. In this period they have worked together for more than 20 years. Thirdly, I study the second of three phases in the building process. In the first phase a kindergarten was constructed. In the two latter phases, two separate residential buildings (with identical roof constructions) are erected. Hence, project management is “up and running” and the relation between the different trades had some time to mature.⁵ Furthermore, the prospect of a subsequent roof makes it worthwhile for the involved parties to consider, how coordination practices can be improved. Of course there are also elements that did not work optimally on this building project. For instance it was obvious, that the local authorities in the municipality had not had many social housing projects during the past years.

A second bias I would like to avoid, is the impact from regulative provisions. Danish contractors often hold it to be impossible to establish long-term relations between contractors due to procurement and tender regulations at national and ECC-level (the former being changed by revised regulations coming into force the 1.9.01). However this claim is not relevant for the case study, which is the sixth building project conducted by the PPU-consortium, which has been granted an exemption from the general procurement and tender regulations. Hence, the limited repetition in working constellations found on the personal level, and to some degree at the firm level, cannot be explained by specific regulative provisions. On the contrary, it was possible and an intended purpose of the PPU-programme to establish long-term

⁴ In some respects however, there are some novelties also at this level: the client and local authorities have not been counterparts on previous PPU.projects.

⁵ The impact of this is somewhat limited for the carpenters, who were replaced midway the project. Consequently, the carpenters making the roof on the kindergarten are not the same as the ones studied in the case study.

relations between firms. In this (limited) sense, the case study may be a critical case: if long-term relations between firms and individuals are not identified on this project, they will probably not be identified on most other projects.

On this background, it was decided to use the multiunit residential housing project located in the Municipality of Gentofte (the northern part of Copenhagen) as a case study. The building project consists of three buildings. The first building is a two-storey kindergarten also housing shared facilities for the residents of the two other four-story buildings containing 43 apartments (ranging from 45-80m²) for singles and families and 24 apartments (ranging from 65-89m²) for elderly persons. The buildings periods for these three buildings were partly overlapping. The client was a social housing organisation and, for the kindergarten, the Municipality of Gentofte. The daily operations of the social housing organisation were taken care of by a client representative, more precisely, a larger social housing organisation. The latter is continuously engaged in house building, but the interaction with the Municipality of Gentofte was novel as this was the first social housing project in the Municipality for decades. Additionally, the specific person representing the client and the PPB-consortium had no prior common working experience.

4.5.1. Identifying the specific part of the building process used as a case study

To study coordination practices in progress for the entire building would be a very time consuming affair amounting to at least 9-12 months of full-time fieldwork (corresponding to the construction time). Hence, after having identified the building project to use as a case study, the next exercise was to “zoom in” on a particular part of the process.

An important part of the case study was to locate the way activities are dependent on each other. For this reason, it was decided to study the coordination practices involved in roof construction. As roof production is towards the very end of the construction process, the interdependencies with other parts of the building process can be estimated based on experience. If some of the earlier processes had been studied, the interdependencies would partly concern the future, and

hence the respondents would to some degree have to make guesses about the interdependencies.

This of course raises the question of how representative roof construction is to building in general. In the above it was argued, that I had no compelling reason to assume, that one type of building would vary significantly from other types of building. The subsequent data collection seems to confirm this initial assumption along most dimensions.

With respect to coordination practices, carpenters from the first and second team expressed that the events on the roof were nothing particular. On the other projects they had worked on, they usually experienced approximately the same level of “project errors”, the same interaction with other trades and the same way of (not) communicating with other contractors, project management and the design team. Further, the two carpenters from the second team with 30 years of experience did not find, that issues relating to interdependencies between activities and project errors due to lack of information and communication had changed much in their professional career. For five activities – carried out by a plumber, a crane driver, a person doing the roofing felt and two different carpenters respectively – the craftsmen were asked if they during this or previous building projects, had experienced, that he or some of the other persons working on the site had changed their way of performing activities. In all cases the answer was “no”, which also seems to confirm the picture, that the observations are not very time dependent.

However, on two dimensions carpenters from the first and second team spontaneously reported deviations concerning the used coordination practices. The first dimension relates to refurbishment. As reported in chapter 6, the degree of unforeseen conditions is very high in refurbishment and consequently, the craftsmen are more involved in providing the solutions (or put differently, the solutions are to a lesser degree specified *ex ante* by the design team). Secondly, the carpenters also reported coordination practices to be different on smaller projects where more decisions are taken unanimously and directly between the master or clerk of work from the different trades (again giving the design team a more limited role than the one found in the case study). As this suggests, one should be careful to generalise the findings of the case

study to small projects like single family houses or to refurbishment (even on a larger scale).

The question on the generalness of roof construction was also addressed in an interview with the foreman for the carpenters. He did not find that the observed interdependencies and coordination practices would have been different if (a) the roof was not made on a house but another type of building, e.g. an office or industrial building; (b) if the client was not a social housing organisation (but e.g. a private or institutional investor); (c) if the project was made 10 years ago; (d) if the project was located in another part of the country; and in contrast to the other carpenters, (e) if the project was bigger or smaller. However, in agreement with the other carpenters, he did find that interdependencies and coordination was different in refurbishment than in roof construction on new houses.

With respect to regional differences, it should be noticed, that during his career the foreman has been working mainly in the Northern part of Zealand. In fact, the statistical information provided in appendix C on years of establishment for firms and the interrelated measure on year of employment of the individual worker, suggest some regional differences between Zealand on one hand, and Funen and Jutland on the other. This data suggests, that high turnover in firms and employees in particular (but compared with manufacturing, not only) is a characteristic of Zealand. The exact reason for this would be interesting to dig into, but can at the present stage only be guessed upon. One possibility is that demand in Jutland and Funen is more stable due to a larger share of maintenance (unfortunately it is not possible to check for this by combining figure 4 and 6 in chapter 5). A related possibility is that up- and downswings in demand in particular applies to larger cities in which case Zealand, homing Copenhagen, presumably is most vulnerable.

4.6. Reliability

Reliability relates to whether a later investigator - following exactly same procedures as described by an earlier investigator and conducting the same case study all over again - will arrive at the same findings and conclusions (Yin 1989). The concept of reliability acknowledges that observations are not objective as data are collected and interpreted by

individuals. However, with reliability it is insisted that the impact of the specific individual conducting a case study should be limited as much as possible. This replaces a criterion of objectivity with a criterion of intersubjectivity (Andersen 1990).

An important part of ensuring reliability is to display the procedures used for collecting data, as well as character and amount of collected data. These issues are considered in this section.

4.6.1. The questionnaire and operationalisation of main concepts

In order to guide my observations as well as questions, I used a structured questionnaire for collecting data. A set of basic questions were asked for each activity performed on the roof (see figure 2 in chapter 6 for an overview of activities). Some additional questions were asked, when the situation gave time and room for it. The questions were tested and modified in a test-study, conducted at the same building project, of coordination practices used during instalment of windows.

Some parts of the construction process may be more informative than others with respect to the coordination practices used during construction. Originally, I planned to collect data at the weekly site meeting (in which access to the interaction between the various trades could be given with a limited time invested). However, I was “warned” by experienced people within the sector (but working on other building projects), that the site meeting only gives a very partial picture of what is going on in the process of construction. An important function of this meeting is to clarify extra payment and reasons for delays (potentially leading to withholding of payment) meaning that the participants are very aware of which information they pass on and which information they retain. So even though site meetings have been used for empirical studies on the site construction (see for instance Kreiner 1976), it was decided to use the questionnaire directly in connection to the craftsmen’s execution of the activities.

Questions identifying the activity

The first part of the basic questionnaire identifies the content of the activity (or set of activities) and the persons who execute them (as I became acquainted with the craftsmen this question became superfluous).

Question	Scale
<i>What is the name of the thing you are doing now?</i>	<i>Text</i>
<i>What is your name (and from which company)?</i>	<i>Text</i>
<i>Which persons take part in this job?</i>	<i>Text</i>
<i>Try to describe the operations of this job⁶.</i>	<i>Text</i>

By regular presence on the roof throughout the entire period of construction, it was possible to map all 18 activities involved directly in making the roof. To recall, an activity is characterised by being a continuous performance of one or more task conducted by a single person and resulting in a tangible or intangible transformation. A few words on operationalisation are required here. Firstly, as I due to time-constraints mainly, but not solely, probed into coordination practices at the level of the craftsmen, the activities all resulted in tangible transformations. Secondly, when one person takes over from another, clearly this constitutes a new activity. However, when the same person work on the same part of the building, it can be difficult to tell whether it is continuous or not (and hence if coordination due to a time-span is required). In order to limit the number of observations (and the number of questions I had to trouble the craftsmen with), I only considered the tasks to be a new activity, if a new person was involved.⁷ A second issue of operationalisation is that in many cases, two craftsmen from the same trade worked on the same part of the building at the same time. When they performed subsequent tasks, these tasks were perceived as different activities. However, when they performed the same tasks in parallel, this

⁶ I used the term “job” (“opgave” in Danish) which is a more popular term than the rather formal term “activity” (“aktivitet” in Danish) used throughout this work.

⁷ In the figure on activities involved in roof production shown in chapter 6, some activities have been split up in order to illustrate the major tasks involved in roof construction.

was considered as duplication and not different activities. In these cases, I only interviewed one of the craftsmen.

Questions on the division of labour and specialisation.

A set of questions relate to the division of labour between craftsmen and specialisation between firms.

Question	Scale
<i>What is it particularly important to be good at in order to carry out this job?</i>	<i>Text:</i>
<i>To what degree would other craftsmen within your firm be able to perform the job you are performing here?</i>	<i>1: All of them 2: Most of them 3: Approx. half of them 4: Only a few 5: I am the only one</i>
<i>To what degree would craftsmen from your trade but from other firms be able to perform the job you are performing here?</i>	<i>1: All of them 2: Most of them 3: Approx. half of them 4: Only a few 5: I am the only one</i>
<i>Why do you think that you were assigned to this particular job?</i> <ul style="list-style-type: none"> – Particular knowledge about how to execute this job. – Previous experience working together⁸. – Randomness. – Other reasons (e.g. health). 	<i>(5-point Likert Scale for each option)</i> <i>1: Decisive 2: Very important 3: Somewhat important 4: Not very important 5: Not important at all.</i>

The first open question aims at identifying the skills involved in the working process in order to see, if very specific or general skills were stressed. The answers given to these questions were of a mixed quality, as it was obvious, that the craftsmen took their skills for granted and therefore often did not consider them at all when answering. For instance, a carpenter replied, that for this particular activity “it was only

⁸ This of course does not inform us about why a group of people are appointed for a particular job – only why people are grouped together in a particular way.

important to be strong”, even though the activity to me clearly involved several technical skills.

The next question concerns specialisation within the firm and the third specialisation between firms. As it turned out, the answers were very uniform (i.e. they replied in favour of no specialisation within or between firms) and for that reason, I did not bother the craftsmen with these questions for each activity.

A related question (the fourth) concerns the reasons for delegating particular persons to a job. The idea is simply, that different degrees of specialisation will result in different criteria used for job delegation. One category was left open (“other reasons”). As it turned out, health reasons were often mentioned as the reason for job delegation in this category (for instance, the senior carpenters were not appointed to the tough (for the knees) job of putting down floors).

Information on these activities has been collected for seven activities (three for carpenters, one for plumbers, one for roofing felt contracts, two for haulage and hoisting of materials). The limited data set refers to the fact, that with respect to the carpenters, the data was supported by observations at the workman’s hut in the morning, when jobs were delegated. Secondly, the answers given also provided information for other activities. For instance, when specific qualifications were not mentioned as a reason for being delegated to the jobs subject to inquiry, it would not be logically consistent, if specific qualifications were used for delegation of other jobs (because in that case, the specific qualifications of not having specific qualifications would be the criteria for job delegation).

Questions on activity variability and activity complexity

During the case study it was observed how the same craftsmen conducted various activities on the roof as well as elsewhere on the building project. The exact input and output and to some degree the tools and working procedures differed for these activities. Hence, within the building project, there is obviously a rather high level of activity variability. However, this does not inform us of the level of activity variability from one project to another. The first of the following question addresses this issue by examining, whether activities that look similar from one project to another, actually are alike when it comes to

the working process. Question two locates the degree to which the *sequence* of activities differs from one project to another. The idea is to check whether sequencing can be the cause of variability even in cases, where the outcome in principle is supposed to be the same from one project to another.

Question	Scale
<i>If you think of other building projects, where you performed an identical job, have you in this particular project been influenced to do the job differently from what you expected, for instance due to the way previous jobs in this project were completed?</i>	1: Not at all, 2: A little 3: Some, 4: A lot, 5: Completely.
<i>Is the sequence of jobs in a building project different from one project to another – to which degree does the moment, at which this particular activity is carried, out differ from one project to another?</i>	1: Not at all, 2: A little, 3: Some, 4: A lot, 5: Completely.

Another set of questions relates to activity complexity as the question focuses on the time spent for search and processing of information in order to find out how to perform an activity.

Question	Scale
<i>How much time do you spend on preparing the job – that is finding out how to perform it – compared with the time spend actually executing it?</i>	(5 Point Likert Scale) 1: Almost all time spent on executing it and no time spent on planning. 5: Almost all time spent on planning it and no time spent on executing it.
<i>How many hours do you have to work on this job before you feel absolutely confident with it?</i> <i>How much time will you save on preparing this job if you should repeat it straight away?</i> <i>How much faster do you think you will be able to perform (preparation included) if you should repeat it straight away?</i>	Hours: 1: Nothing 2: A little, 3: Some, 4: A lot, 5: Completely. % :

The first of these two sets of questions relates directly to the time spent on planning. The next question is based on the idea, that activities, which are not well known to the person who performs it and/or is not easy to solve, will take longer to get confident with. Hence, the more hours spent on the activity, the higher a task complexity. The last two questions are based on the assumption, that the learning curve levels off with increased repetition/decreased task complexity. Thus, high values reported for question five and six will be considered identical to high activity complexity.

After the three first interviews it turned out that these questions on variability and complexity did not work very well. First of all, it became clear, that the answers depend very much on the respondent expectations. For instance, low values were reported for answer one (the activities where not performed very differently from the expectations of the craftsmen). At the same time, it was observed, that a range of other activities affected the activities studied in a very particular way. When the craftsmen were confronted with this, in my view, apparent contradiction, the reply, was that they did not consider it to be different

from expectations, because they expected it to be different. Likewise, the sequence of activities (question two) did not differ much; it always differed. And finally, as the craftsmen were used to work with new activities (question four), they felt confident with a new - and not very well defined concerning the procedure - activity from the beginning. The questions of preparing versus executing the activity (question three and five) made little sense to the craftsmen, as they appeared to find out how to perform the activity, while they performed it. Finally, question five and six was difficult to answer due to their hypothetically nature - as the craftsmen did not repeat the activities straight away, they did not know the impact of repetition from experience.

For these reasons, even though the answers given can be seen as an indirect support of the high task complexity, the estimation of task complexity had to be measured by other means. One way is to look at the skills and educational level of the craftsmen. Another way is to look at the degree and strength of interdependencies, that is, how and how much the performance of each activity is affected by other activities (as discussed below).

Questions identifying the interdependence of activities

One set of basic questions identifies the interdependence of activities.

Question	Scale
<i>What other jobs in this project affect the execution of this job? It can be jobs prior to or after this job.</i>	<i>Name of activities</i>

Having identified the interdependencies, they were specified in accordance with the following matrix:

Name of activity N	Activity X	Activity Y	Activity Z etc
Kind of dependence	(5 point likert scale)	(5 point likert scale)	(5 point likert scale)
Time-dependence			
Material-dependence			
Tool-dependence			
Method-dependence			
Access-dependence			
Damage-dependence			

As seen, interdependencies are decomposed into different sub-groups:

- *Time-dependence*: the degree to which other activities have to be completed before this activity can be commenced;
- *Material-dependence*: the degree to which other activities affect which materials to use for this activity;
- *Tool-dependence*: the degree to which other activities affect which tools and equipment to use for performing this activity);
- *Method-dependence*: the degree to which other activities affect which methods / working procedures to use for this activity;
- *Access-dependence*: the degree to which other activities physically obstruct the physical accessibility needed for carrying out this activity); and
- *Damage-dependence*: the degree to which other activities affect the quality of the result of this activity, for instance by damaging or making the outcome dirty.

These different kinds of dependencies were observed in the test-study of the instalment of windows.

The answers were given according to a 5-point scale ranging from “not dependent at all” to “completely dependent”.

The dataset consisted of 18 observations (i.e. activities). As interdependencies not directly involved in roof production – e.g.

activities concerning planning of the roof or completion of other parts of the building – were reported on eight occasions, the total number of nodes (i.e. activities) in the network is 26.

A set of additional questions tried to estimate the extent of delays, as well as change in working procedures caused by interdependencies. The reason for asking these questions is, that information on the existence of interdependencies does not inform us about their impact. The interpretation of the answers given to these questions turned out to be very difficult. Often, the craftsmen replied that they were not very much delayed due to a delay in the completion of previous activities even when these were weeks or months behind the official timetable. However, as it will be seen in chapter 6, a constant reallocation between various activities is an important way of optimising the use of manpower. Hence, the craftsmen did not consider themselves to be very delayed simply because they did not expect to commence before the previous activities were completed. In a similar way, they did not expect the input from previous activities to be of a very specific nature. So, even though these questions were abandoned at an early state, their “meaninglessness” is important evidence on how coordination in construction is done by a “slack” timetable (the deadline for finishing the overall house is fixed but the exact sequence of activities is not) and a great activity variability.

An interdependence is a potential source for coordination. Hence, by estimating the number of interdependencies, or rather the number of different actors involved in activities on which an activity is dependent, the *number of actors* potentially⁹ involved in the act of coordinating an activity with other activities can be assessed.

Questions identifying the coordination modes used during roof construction

The final part of the basic questions asked for roofing-activities concern the information principles by which activities are coordinated. The

⁹ It is important to stress “potentially” since it in some situations can be desirable to disregard the impact of some of the, say, weaker or hardly recognisable interdependencies. This will most likely result in higher indirect coordination costs (costs due to a less efficient coordinated state) but will on the other hand reduce the cost directly involved in coordination (for instance the cost of identifying interdependencies).

person performing the activity was asked: “When you carry out this job, how do you find out how to do the job?”. The respondents were asked to specify the question according to the following matrix:

Coordination object	Who to conduct activity	When to conduct	Which materials to use	How much to produce	How it should look like	Which tools to use	How to do it	If quality is OK	What to do if in doubt
Coordination mode									
Authority 1 - Instructions from foreman									
Authority 2 - Instructions from clerk of works / management of firm									
Authority 3 - Instructions from project management									
Authority 4 - Instructions from architects and engineers (e.g. drawings and instructions).									
Pricing – using the contracts signed when tendering took place.									
Teaming – talking to other craftsmen, suppliers etc.									
Formal rules – Using general and written line of directions (e.g. instructions for use).									
Social norms 1 – by accessing the task and use my experience.									
Social norms 2 – not something I think about, I do as I always do.									
Other									

The matrix is derived by juxtaposition of the *coordination object* with different *coordination modes*.

Coordination objectives represent different areas in which information was exchanged. The objectives were identified during the test study of instalments of windows and includes information on: *Who* and *when* to do the activities; which *materials* to use and the *extent* of the work (how much to produce); the *finish* (look) of the output (if any further requirements than the one given by the materials and the extent of the work); and which *tools* to use and *how to do* the job. Finally, there is

exchange of information with respect to *quality control* and *resolution of doubts*.

The typology of *coordination modes* is an adaptation of the typology of Grandori (1997, 2000) (as discussed in chapter 3) customised for construction during the test study.

Besides adjustment in language (making the concepts easier to understand for the people on site), the customisation of Grandori's typology is based on the following reflections.

Authority is, according to Grandori, characterised in that a central agent makes decisions on, and control of, subordinates' behaviour. In this view, it would be expected, that at the level of the worker (or more precisely, the craftsman), authority is characterised by orders, commands, instructions and the like (for matter of simplicity summarized as "instructions" in the matrix above).

This approach to authority seems to fit well with the classical statement of Coase (1937, p. 404) in which direction includes the right to tell and control "when to work (within the hours of service) and when not to work, and what work to do and how to do it (within the terms of such service)".¹⁰ Based on the case study, I found, that on some occasions these instructions were offered by a employee-employer relation within the same firm as the craftsmen, i.e. either by "Instructions from foreman" and by "Instructions from clerk of works / management of firm". However – in contradiction to Coase's perception – persons (usually) in external firms were also mentioned as a source of directions; more precisely, the craftsmen did receive "Instructions from project management" and "Instructions from the design architects and engineers".

As noticed by N. Foss (2000 d, p. 40) "Authority is a dangerous word because it is easily invested with a too narrow meaning, for example detailed direction and supervision. However, authority also means setting boundary conditions for a relation....And ultimately, the meaning of being a boss is that one can restrict the decisions of one's

¹⁰ As indicated in the brackets, and as later explicated by Simon (in 1951), this right to give orders are not unlimited as some constraints between employer and employee is negotiated initially (K. Foss 2001c).

subordinate, overrule him and perhaps fire him. In turn this means, that although decision rights may be delegated, we can still trace the chain of authority in a firm, and we will always realize that ultimate decision-making power resides at the top. In this sense, all subordinates' decision rights "are loaned, not owned" ...".

This note raises three remarks with respect to the present discussion of an operationalisation of Grandori's typology. Firstly, it should be acknowledged, that this typology indeed is exposed to the risk of only focussing on the more direct elements of authority provided by directions and orders. In agreement with N. Foss it was found, that in order to understand the role of authority in sofa producing, the "boundary conditions" provided by tools, working procedures and dies has to be included (see discussion on impersonal authority in chapter 7). However, authority by these, and presumably also other, means will properly be very difficult to identify by asking, due to their indirect character. Other methods for data collection - for instance observations and interviews on the degree to which management engage themselves in defining such guiding structures - seem to be a less insufficient way of assessing these aspects of authority.

Secondly, it should be noticed that an authority relation might exist between two parties without manifesting itself for a specific activity, as decision rights can be "loaned" to the subordinate - or coordination by "agency", as Grandori terms it. Since coordination by agency is characterised as when information is given by instructions from superiors for some activities and not for others, it is not included in the matrix on coordination modes used for single activities.

And finally with respect to the "chain of authority", it may very well be the case, that at the same time as craftsmen receive information via instructions from people in external firms, these instructions are supported by a set of contracts between the contractor and subcontractor (for instance a contract reached during a process of tendering) and between the subcontractor and the craftsman. It should, in other words, be kept in mind, that the purpose of the coordination matrix is to identify information flows (and not contractual relations as such), and that the principles used for handling information can change from one organisational phase or level to another.

According to Grandori, the key characteristic of coordination by *price* is that all transferred information is contained in prices. Based on this information, each agent uses his local knowledge on his own productive or consumption activity to make an independent decision on what to produce, when to produce etc. As emphasised by Grandori (1997), *pricing* is usually supported by other coordination modes. In the case of construction, before a subcontractor locally decides on his price for performing an assignment, the design team has usually provided tender documents or similar descriptions of the extent of the work, deadlines etc. Thus, in this matrix coordination by *pricing* has been made equivalent to using the information provided by the contract signed *ex ante* production.

As “all contracts, with the sole exception of pure spot market contracts, contain some instructions, restrictions or are accompanied by orders” (K. Foss 2001c), some of the instructions given from architects and engineers (referred to as “Authority 4 – instructions from architects and engineers”) may in fact relate to these initial contracts. On the other hand, due to among other things “ad hoc planning” and “project errors” (see chapter 6), it will not be correct to comprise these instructions under the label of “pricing”. Since the craftsmen are usually not involved in external contractual relations (and consequently do not know the source of the instructions), the category “Authority 4...” is likely to contain information provided by authority as well as by pricing.

In coordination by *teaming*, information is (according to Grandori) transferred without any hierarchy, and decisions are made jointly and unanimously. In the case study, coordination has been classified as *teaming* when the craftsmen answered, that they obtained information by talking directly to and agreeing with the other persons involved in production. This category can also contain elements of coordination by negotiation as the test study showed, that the difference between decisions made unanimously (without conflicts) or jointly (with some elements of conflict) is very subtle.

Coordination by *norms and rules* is the last of the four pairs of coordination modes outlined by Grandori. Here, actions are based on knowledge that is common within a given context rather than pertaining to calculations of interests and processing of information. Grandori defines rules as being formally expressed and thus this is the

terminology used here. In the matrix, rules are exemplified as “using general and written line of directions”.

Norms are perceived as socially defined – i.e. they are not formally expressed. In the matrix, they have been split into two in order to distinguish, how ingrained they are in people possessing them (and hence how much information processing there is involved). Some norms need to be activated by a conscious effort (“by accessing the task and use my experience”) whereas others are so deeply rooted that no estimation is required (“not something I think about, I do as I always do”).

The interviewed people could answer on the use of coordination modes and coordination objectives on a five-point likert scale (1: Not at all, 2: only to a small extent, 3: to some extent, 4: to a large extent, and 5: completely). The dataset on coordination modes for the roof case consisted of reports on 12 activities. Eight activities performed by carpenters (construction of roof houses, making heads, erection of rafters, installing edge strip, covering rafters with wooden plates, wooden frame for eternit-covering, installing gratings, installing plates of eternity); one activity by the crane driver (delivery and hoisting of building materials); one activity by the roofing felt contractor (making the roofing felt); one activity by the ventilation contractor (installing ventilating plant on roof); and one activity by the plumber (installing the gutter). Notice that for practical reasons I was not able to make reports for coordination modes used by producers of the carcass and by the surveyor.

As seen, the matrix used for the question on coordination modes contains information about the place of employment. Hence, besides informing us about the coordination modes used during construction, the matrix also contains information on *the organisation of coordination* (i.e. the degree to which it is done within or between firms).

The questions presented so far only describe the present use of coordination modes. The degree to which these modes ensure little indirect and direct coordination costs and hence the degree to which they are the best of alternatives, is not addressed. In order to probe into this aspect, a set of additional questions explored, how satisfied the craftsmen were with the used coordination modes and if they could think of better alternatives. And if “yes”, what in their opinion prevented these alternatives from being realised. It turned out, that these additional

questions were very difficult to ask for each of the 18 activities. First of all, they are very “time-consuming” and not easy to fit into the natural breaks. Secondly, in order to answer, the respondents have to understand the typology I used on coordination modes – again the possibilities of explaining these on top of the roof while the craftsmen tried to follow the pace of the piece work contract was limited. Furthermore, it did not give the respondents room for expressing themselves in terms with which they were familiar. Consequently, I addressed these questions in a more open manner on occasions where there was room for talking. In particular, this was possible, with the carpenters with whom I socialised the most.

Additional questions

Finally, a set of additional questions relates to innovation within (“Have you, in this or previous projects, changed the way you carry out this job?”), between (“Have you, in this or previous projects, changed the way you interact with others when carrying out this job?”) or in neighbouring activities (“Have you experienced that people in neighbouring activities, in this or previous projects, have changed the way they carry out their job?”). If an innovation was identified, its nature (“Is it a product or process innovation?”) and its origin (“Who got the idea and how did the innovation develop?”) was investigated. However, since innovation is not a core feature in this dissertation and since initial inquiries did not find evidence of any innovations, these questions were not considered systematically.

4.7. Explorative and explanatory case studies and strategies for data analysis

Different strategies can be used in order to analyse the data collected during a case study. As the choice of analytical strategies depends very much on the type of the case study, let me briefly explicate the status of the case study used here.

Ultimately, the case study on roof construction aims at being *explanatory* – I would like to explain why certain coordination modes are used during the construction process (recall the overall research question). However, before this question can be addressed, knowledge on the existing coordination practices has to be acquired; for instance “what are

the coordination modes currently used during construction?” or “who are the major actors partaking in coordination?”. Hence, the case study is to some degree also *explorative*. This explorative element reflects, that the existing empirical knowledge on coordination practices (understood in an information-perspective) is limited.

Due to this relatively “immature” state of current empirical and theoretical research on the issues considered here, it is difficult, as well as undesirable to develop very specific hypotheses or propositions *ex ante* the field work (Yin 1989). Rather, the theoretical framework can and should point out some concepts and trade-offs, that are likely to be of relevance for the empirical analysis. This theoretical framework can then be compared and contrasted with the empirical findings during and after the case study is conducted (Eisenhardt 1989).

As this suggests, in the work at hand, there is a rather close interplay between theoretical and empirical reflections. Rather than first developing theory, then collecting data and then doing the analysis, to a large extent the theoretical and empirical reflections co-evolve. In this thesis, this is reflected in two ways. Firstly, some of the empirical insights are taken on board from the very beginning (e.g. in the research questions). And accordingly, the theoretical chapters (chapter 2 and 3) are to some degree targeted at understanding coordination in a setting typical to construction. Secondly, propositions have not been developed during the theoretical part. Rather, the theoretical part has been used for developing a framework that points out some potentially central concepts and causalities.

Thus, a strategy for analysing data relying on *theoretical propositions* has not been found useful for this case study. As an alternative, a *case description* has been used for presenting and analysing the case data in chapter 6 (Yin 1989).

Chapter 5 – Unstable markets and non-repetitiveness in relations of firms and individuals

5.1. Introduction – non-repetitiveness in markets and firms

In the theoretical part it was argued that repetition of activities and working constellations is important to the way coordination is organised within or between firms, and how it is handled by different coordination modes. It has further been claimed that construction faces low degrees of repetition on these dimensions at least partly due to change in overall demand. The purpose of this chapter is to substantiate this claim by analysing the way fluctuations at the sector level appear to propagate into the levels of firms and individuals.¹ Further, the chapter will provide the first empirical indications on the organisational responses to these fluctuations; in particular the existence of *trades*, *craft production* and *trilateral coordination*.

Thus, this chapter illustrates how change (i.e. lack of repetition) at one level can trigger change at other levels. In the following some evidence is given on how lack of repetition at the level of the market (between value chains) seemingly creates lack of repetition at the single building project (within a value chain). This emphasises why coordination of activities involved in a single product cannot be understood without considering the way coordination is done between products.

The content of the empirical part of the thesis is structured according to the interplay between changes in markets and in the single building project. This chapter starts by considering change at the market level and give some ideas of how these changes flow into changes at the level of firms and individuals. As part of this, the chapter provides sector-wide evidence on organisational responses – in particular relating to

¹ In the following, I will assume that change in demand largely determines change in supply and not the other way around. This assumption may be justified for this particular sector with reference to the existence of many small firms presumably having none or extremely little possibilities to affect prices. Even though this chapter analyses how the macro-level impacts on less aggregate levels, it should not be ignored that in some situations processes at the micro level can also affect the macro-level (Coleman and Hao1989). For instance, changes in aggregate demand implies less specialisation at the level of firms and individuals which in turn, as suggested in the discussion in chapter 8, creates a system characterised by little overall innovation.

specialisation and the division of labour – taken by construction firms. Chapter 6, in which an example of roof construction is analysed, is fully devoted to understanding coordination at the level of the single building project.

The data on fluctuations on the market level are mainly derived from ordinary statistical reviews. The hitherto untold story on how firms and individuals are affected by, and coping with, these market changes is told by using data from a unique Danish database covering all companies in Denmark. Thus, *all figures and tables in this chapter relate to the Danish Construction sector.*

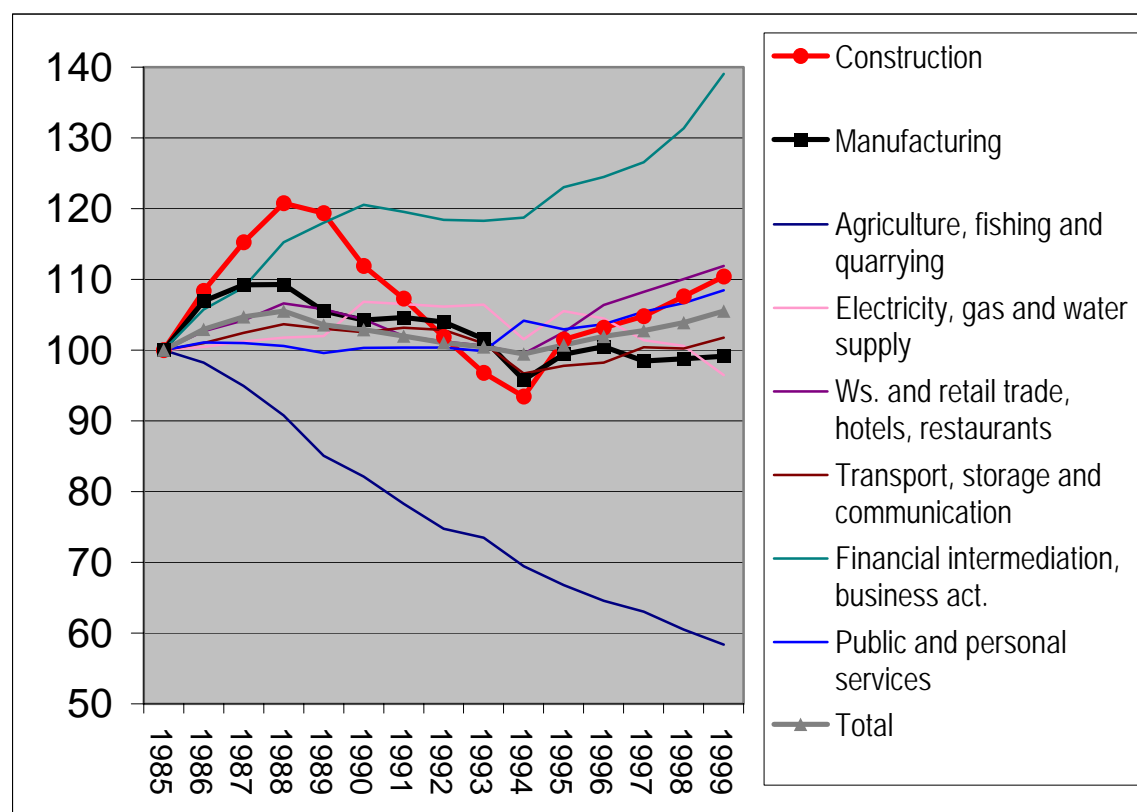
Several reasons to why demand for construction products fluctuates significantly can be given. Some highlight the durability of construction products. As the production of these items is small compared to the total stock, small variations in demand for the finalised products create big variations in the need for building activities (V. Smith 1999, p.p. 402-403). Secondly, investments with long durability are more sensitive to expectations on interest and inflation rates, which themselves are fluctuating. Furthermore, construction is also encouraged or discouraged by the political responses taken to administer trends in for instance, employment, trade-balances, and governmental expenditures and incomes. Hence political responses sometimes smoothen, but other times accelerate the fluctuations of an unregulated market (Wendt 1992). Furthermore, if people make systematic errors about future market conditions, endogenous cycles in demand can occur (Wheaton 1999).

The conditions triggering change in demand are important to have in mind in order to locate industries that might share some of the following characteristics of construction. As pointed out in chapter 2, other reasons than markets to change outside the realm of the single value chain can be imagined: (a) unstable specifications of the product (e.g. customised production), (b) unstable technology, or (c) variable materials or seasonal changes (Stinchcombe 1990). Hence, the lessons learned in this and the following chapter on how coordination is coped with in situations of low repetitiveness might be of relevance to activities within many different industries.

5.2. Non-repetitiveness on sector level

Consider the development in number of people working in different industries shown in figure 1. Here the well-known claim (Bishop 1975, Hillebrandt 1975 and Hillebrandt *et al* 1995, Kommissionen 1997, V. Smith 1999, Miozzo and Ivory 2000, Bang 2002) becomes visible: construction stands out by having periods of high degrees of expansion as well as contraction. This unlike other industries facing stable growth or decline in employment (finance and agriculture etc. respectively) or industries having more permanent levels of employment (the remaining industries).

Figure 1: Employment in all sectors 1985-99 (1985=100)²

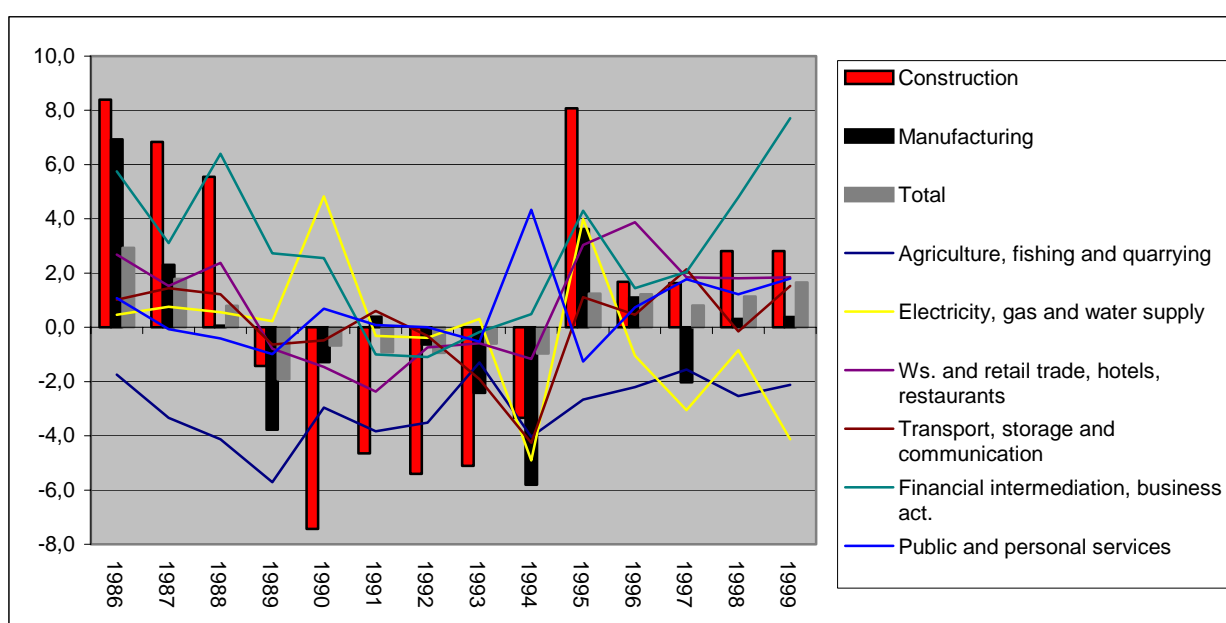


Source: Statistical ten-year review 2000

² The data from the IDA-database used later in this chapter covers the period 1981-98. Hence, it would be preferable to show change in employment from 1981 and onwards and not start with 1985. However, there is a break in data in the general data from 1984 to 1985. A figure on employment trends from 1981-1992 is shown in figure 1 in appendix C.

Figure 1 displays the long-term changes in the number of people working in the different sectors. However, if the changes from one year to another are considered, the magnitude of shifts in employment in construction is probably even more striking (figure 2). The average of the absolute value of annual employment changes in the period 1985-99 is 4,4% for construction whereas it is 2,2% for manufacturing firms. Furthermore, it also takes on very different values from one year to another. For instance construction firms had to lay off approximately 4% of its workforce in 1994 only to expand by approximately 8% the following year.

Figure 2: Change in employment from previous year (percentage points) - all sectors 1985-99



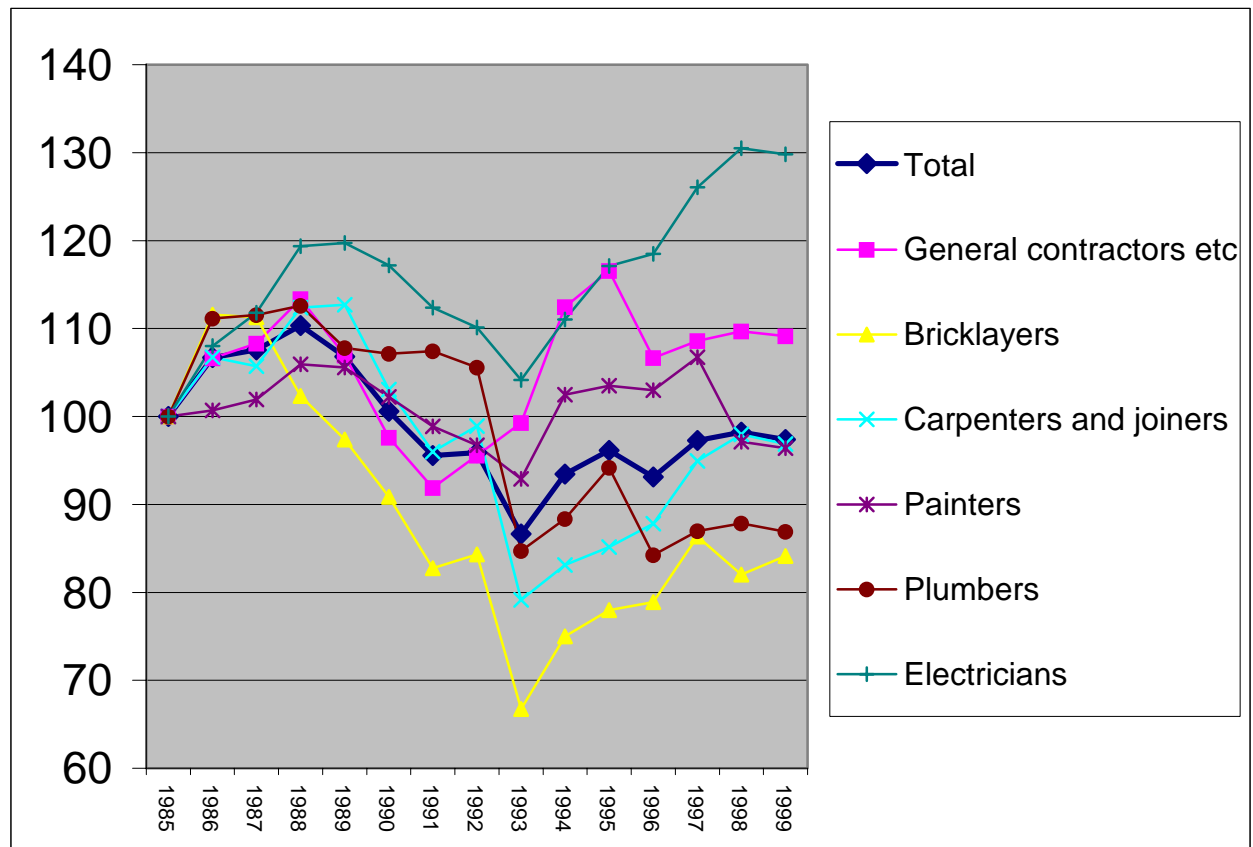
Source: Statistical ten-year review 2000

Taking a more fine-grained look at fluctuations would display even higher degrees of fluctuation in employment in construction due to its seasonal character. Seasonal data for building and construction in Denmark from 1993 to 1999 illustrates that the aggregate turnover drops with approximately one third from the summer to winter (Danske Entreprenører 2000)³.

³ This phenomenon must of course be assumed to be highly dependent on the climate. However, it should be taken into account that the Danish Government for many years has given extra financial support to building projects performed during wintertime hence reducing the seasonal impact of the

Importantly, the different trades all follow the general trend in employment, that is if employment goes down in, say, plumbing firms, it also goes down in, say, carpenter firms (figure 3).⁴

Figure 3: Employment of wage earners and working masters in the private construction sector - different trades 1985-99 (1985=100)⁵



Source: Statistical ten-year review 2000

The fluctuations in supplied labour obviously relate to changes in demand. The harsh fluctuations at the level of the industry and of the

climate.

⁴ The figure also displays an overall trend where, if the importance of fluctuations in overall demand is omitted, more people constantly are employed in especially electrician firms, but also contractor firms, and less people are employed in bricklaying firms.

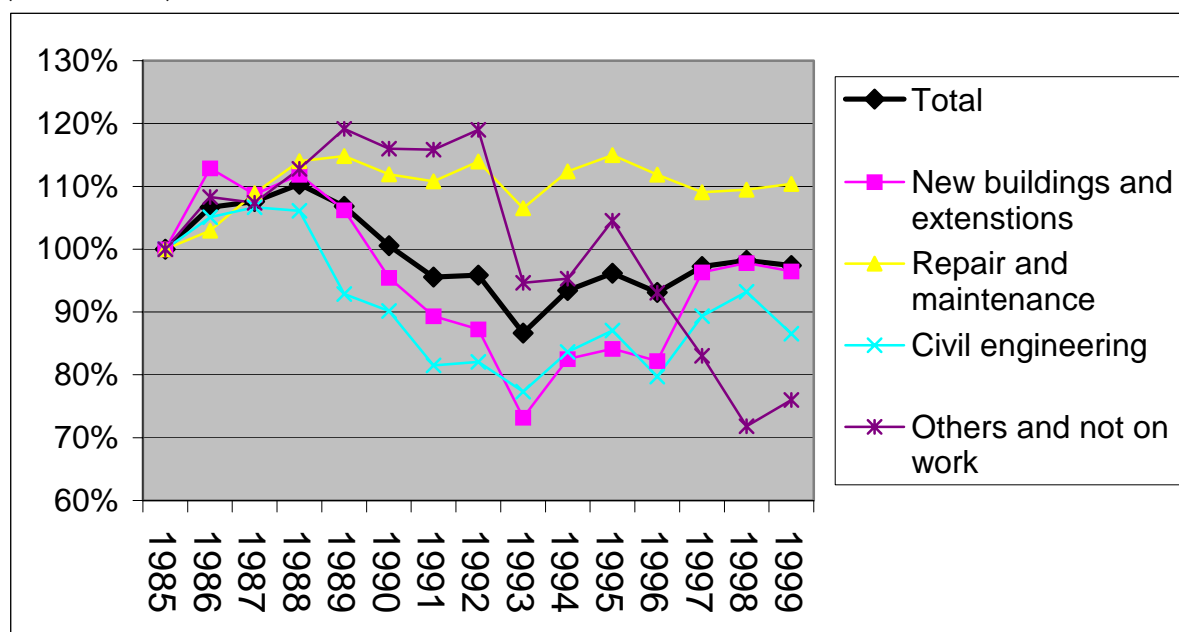
⁵ Unlike the two previous figures, in this and the following figure, owners, salary earners and other employees are not included. Furthermore, the principles for counting differs as well. Thus, the trend in overall employment in figure 1 and 2 cannot necessarily be identical to the overall trend in figure 3 and 4 (in fact it is different as figure 1 and 2 display a 10% increase in the period 1985-99, whereas figure 3 and 4 display status quo for the similar period).

trades indicate that up- and downswings in different segments of the market only to a very limited degree counterbalance each other.

Additional data seems to support this reflection.

Concerning the *type of construction*, house building, construction works (roads, bridges etc.) and other types of construction all follow the general trend in employment. Maintenance on the other hand is less associated with overall fluctuations (figure 4). However the relation is not supplementary (maintenance is not reinforced when other construction activities go down). This clearly limits the degree to which construction firms can keep up employment by moving from one kind of construction work to another.

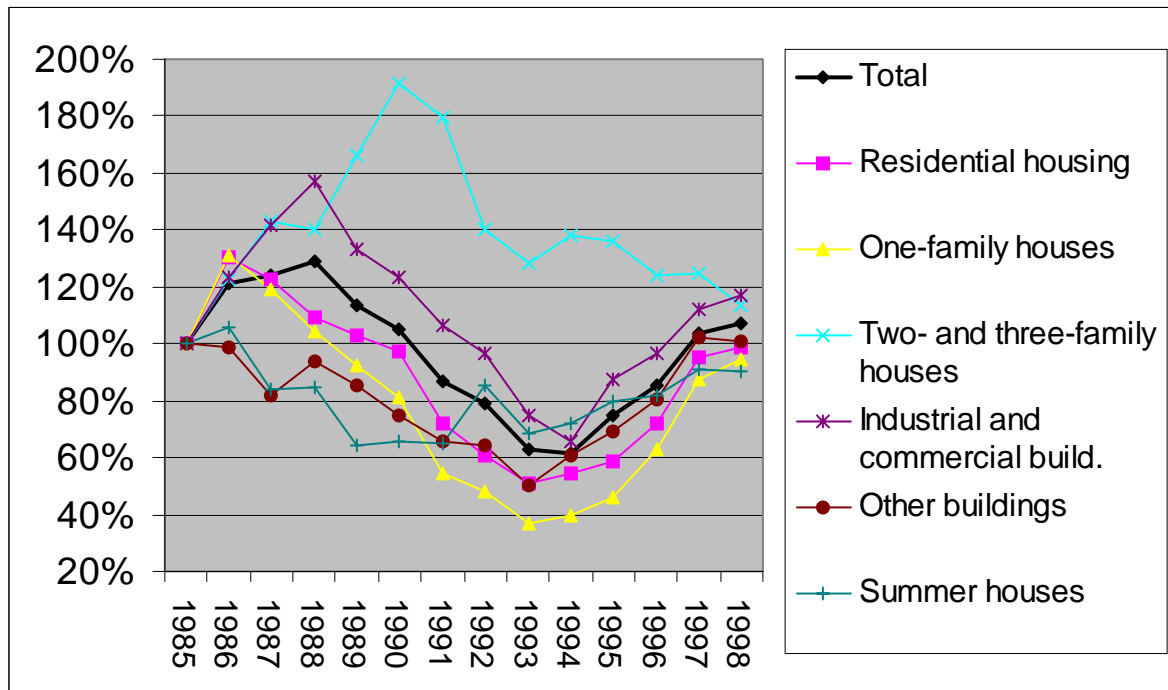
Figure 4: Employment of employees and employers masters in the private construction sector - different types of construction 1985-99 (1985=100)



Source: Statistical ten-year review 2000

If we focus solely on house building (multi-unit houses, single-family houses, terraced houses, offices, summer houses, and other types of houses), the picture is the same: fluctuations are synchronised and roughly of the same relative size (figure 5).

Figure 5: Completed m² - different types of house building 1985-99 (1985=100)⁶

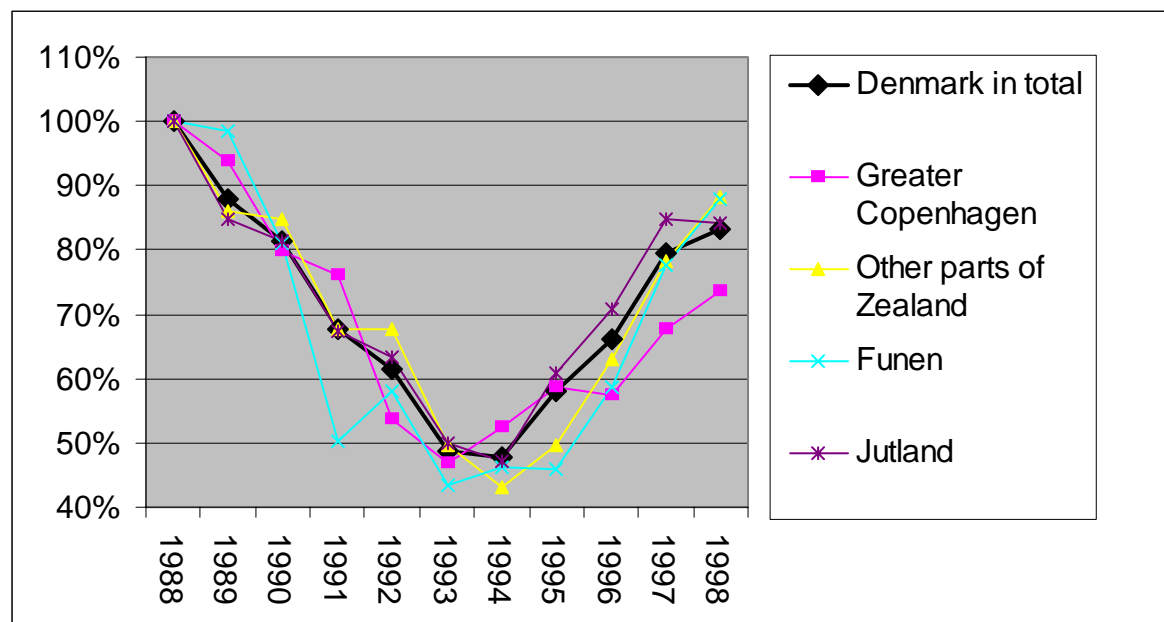


Source: Statistical ten-year review 2000

Concerning spatial variations in demand, rough statistical data once again indicates a very uniform pattern (Figure 6).

⁶ Two and three family houses represent in average only 6,8% of completed m² in the period 1985-98.

Figure 6: Completed m² in construction - Different regions (1988=100) in Denmark



Source: Statistical ten-year review 2000

Obviously, this figure does not inform us of the potential for reducing the impacts of market fluctuations by entering foreign markets. According to the VAT statistics, construction firms only do this to a very limited degree: in 1996, exports represented less than 4% of the turnover of construction firms (43% for manufacturing firms) (Statistisk Årbog 1998, Table 355). Similarly, within the EU, construction imports from other EU-countries represented app. 3% of all public construction activities and close to 0% from countries outside EU (Kommissionen 1997).⁷

In balance, compared with other sectors, changes in demand are very severe in construction. The fluctuations in different segments of a market

⁷ There are two alternative explanations to the low level of export (a) it is difficult to enter foreign markets or (b) there is nothing to gain from it as would be the case if for instance they co-oscillated. Without going into details, experiences from Danish contractors exporting to Germany during the boom of the 1990s illustrates that entering even neighbouring markets indeed is very difficult (Skaates 2001). On the other hand, concerning ad b, one of the explicit reasons mentioned by the large Swedish contractors (notably NCC and Skanska) for expanding their activities in Denmark, was that the national differences in demand would smoothen out their total turnover.

with limited extent of the market make it difficult for construction firms to keep a constant level of employment.

5.3. *Non-repetitiveness on firm level*

Some basic information on construction firms in comparison with manufacturing firms is provided in Table 1.

As seen, the number of construction firms roughly equals the number of manufacturing firms, but since construction firms are much smaller with respect to employees, construction “only” constitutes 20-25% of the manufacturing workforce (and approximately 4% of the total workforce).

Furthermore, the table is also evidence of a different long-term development in size. To a certain degree (as I shall return to later in the chapter) this can be explained by a higher turnover of construction firms, but also construction firms established at the same time as other manufacturing firms exhibit considerably lower growth rates. For instance, the number of full-time employees in 1998 for firms established in exactly 1981 was 28,95 for construction firms and 155,39 for all manufacturing firms (IDA-database, own inquiries 2001). Presumably, this development is, at least partly, associated with different trends in the ratio of capital and labour – an issue on which the IDA-database unfortunately does not shed much light.⁸

⁸ For instance, there is no information of the total turnover of each employee (a higher turnover of each employee could be taken as a proxy for higher capital-to-labour ratio). Merging the IDA-database with account-data could be a promising way to overcome these shortcomings.

Table 1: Number of firms⁹, firm size¹⁰ and total employees in construction and manufacturing¹¹ - 1981-98

Year	Construction			Manufacturing		
	Number of firms	Average full-time employees	Total full-time employees	Number of firms	Average full-time employees	Total full-time employees
1981	21285	5,08	108128	23796	16,33	388589
1989	18601	6,84	127231	23392	18,14	424331
1992	16983	5,96	101219	22201	18,1	401838
1995	16507	7,17	118355	20440	20,54	419838
1998	17155	7,45	127805	19283	21,65	417477

IDA-database. Own inquiries 2001.

But the table also tells us something about the main question of this chapter: how do construction firms cope with the demand fluctuations at the sector level? Basically, adjustment to changes in overall demand (as expressed by number of employees) can take place by two different means: by adjusting (a) the size of firms and (b) the number of firms. The

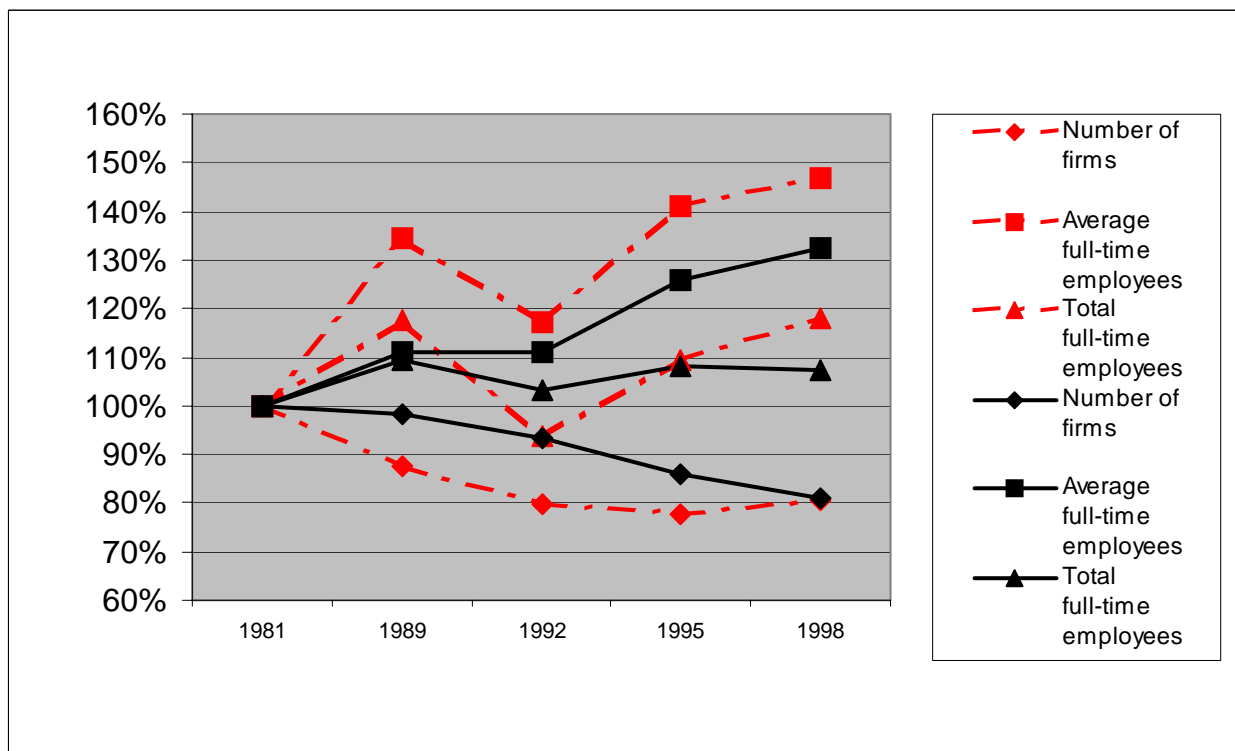
⁹ If nothing else is stated, a firm represents a *working-place* ("arbejdssted") with people employed by ultimo November for the relevant year. A working-place is not identical to *business units registered for VAT settlement* ("momsregistrerede virksomheder"). As the working place is a geographical related concept, a business unit with subsidiaries (but not, say, a construction firm working on building projects in different parts of the country) can contain more than one working-place. On the other hand, firms that have no people employed by ultimo November will not be counted as a working-place. For both manufacturing and construction the number of business units is more than 50% higher than the number of working places in 1989, 1992, 1995 and 1998, suggesting that the effect of not having people employed in November by far exceeds the effect of subsidiaries. Further, the ratio is more constant in manufacturing than in construction, which potentially indicates that in periods of recession, construction firms (defined as business units) are dormant but not necessarily closed down.

¹⁰ Employees are measured as full-time employees. For instance, a person only working half time is counted as half an employee.

¹¹ If nothing else is stated, according to the general categorisation of Statistics of Denmark, construction firms have been defined as Nace-code 451100-455000 and manufacturing by Nace-code 151000-372000. However, in the inquiries for this table, Nace-code 401000-410000 ("Electricity, Water and Gas supply") was included as part of manufacturing. Due to the limited size of firms and employees in electricity, water and gas (in 1998 approximately 4% of full time employees and 8% of working places), the impact of including this group in manufacturing is very limited.

use of these two means within construction and manufacturing industries is shown in figure 7.

Figure 7: Change in number of firms, firm-size and total employees in construction (red) and manufacturing (black) 1981-98 (1981=100)



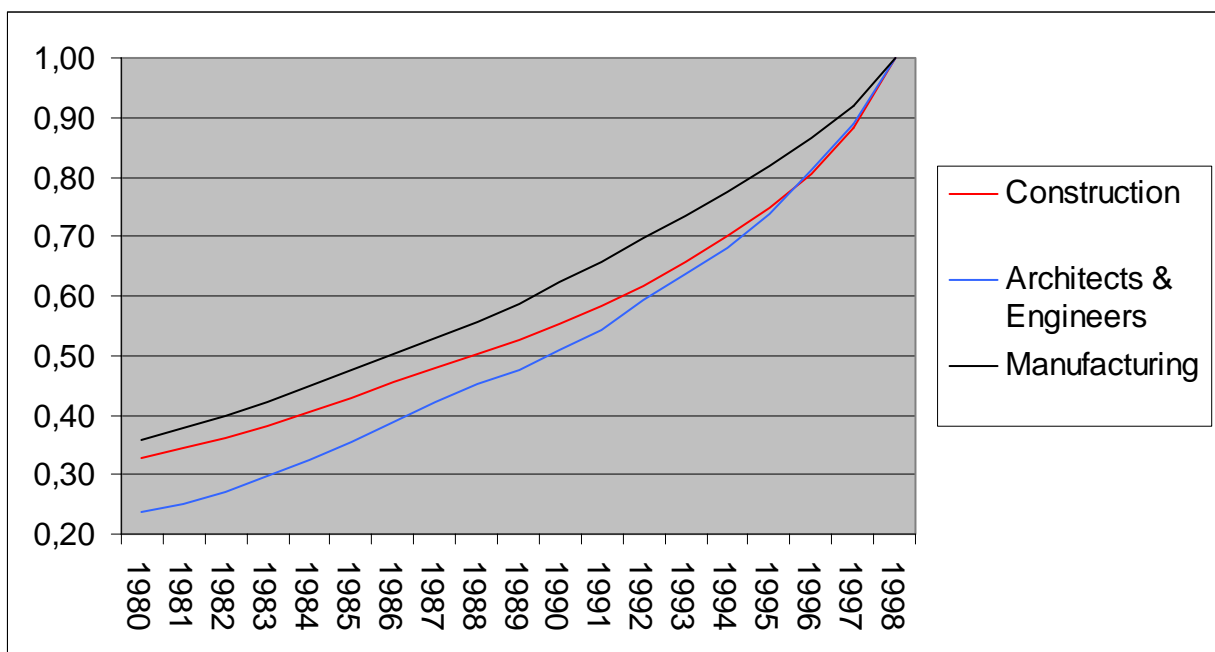
IDA-database: Own inquiries 2001

For manufacturing firms, the story seems rather straightforward: they become bigger and fewer. Even the overall increase in employees witnessed from 1981-89 and 1992-95 cannot outweigh this tendency. For construction, the story is less clear-cut since there are periods of increasing and decreasing firm size as well as ups and downs in the number of firms. However, the divergence can to a large degree be explained in different levels of change in overall employment rather than different ways of handling these. For both construction firms and manufacturing firms applies (although to a different degree) that in periods of mild up and downswings firms become larger and fewer. In periods of more extreme variations this tendency can be counterbalanced, causing increasing number of firms or decreasing firm size.

With respect to the survival and emergence of single firms, the observed pattern in figure 7 suggests that due to higher levels of fluctuations, the

turnover of firms is higher within construction than within manufacturing industries. Or put bluntly, more construction firms will die because there are more periods of step recession and more construction firms will be established because there are more periods of rapid upswings. Rather than having a constant thinning out of an existing stock of companies as in manufacturing industries, construction has a high number of exits and entries. Hence, construction firms are in general younger than manufacturing firms (figure 8).

Figure 8: Year of establishment for construction and manufacturing firms (1998=100)



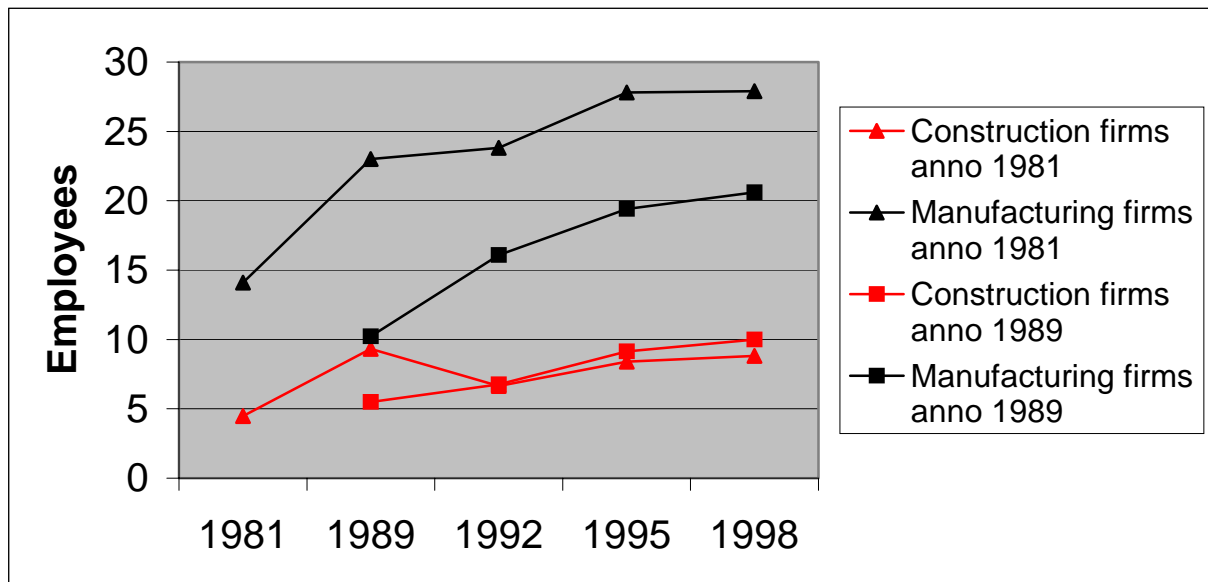
IDA-database. Own inquiries 2001.

The difference in age for construction versus manufacturing firms varies with the regional area. In general firms are younger in Zealand than in Funen and Jutland. However this impact is not as big for manufacturing as for construction. Thus, it is in particular in Zealand that the year of establishment differs between construction and manufacturing firms. Yet, the difference in year of establishment in manufacturing versus construction is significant in all three regions (see Figure 2 in Appendix C).

To some degree, the low age of construction firms can explain the existence of many small firms as firms in general start small and grow

over time. However, even if only firms of the same age are considered, construction is characterised by many small firms (figure 9).

Figure 9: Size (full time employees) of construction and manufacturing firms established in 1981 and in 1989



IDA-database. Own inquiries 2001.

As observed here, both construction and manufacturing firms doubled their size from 1981-1998 as well as from 1989-98. However, as construction firms are only a third or half of the size of manufacturing firms in the year of establishment (i.e. in 1981 and 1989 respectively), the growth in absolute terms is much smaller. Furthermore, in the period of recession from 1989-92, construction firms established in 1981 actually decreased in size. Reasons for the existence of many small firms in construction are further discussed in chapter 8. One of several potential explanations pointed out here relates to the specific role that the construction firm takes (or rather does not take) in coordination. As argued in chapter 2, a high level of external change limits the potentials from integrating subsequent activities within the firm. Unlike manufacturing firms in general, it would be expected that construction firms work at low costs even when only performing a single activity “here and there” in the value chain. Thus, the small growth in firm size is perhaps a sign of *bilateral* and *trilateral* coordination.

Even though the main difference between construction and other kinds of manufacturing presumably is within entries of firms, construction is also above average concerning exits. If we look at the stock of companies

in 1981, 28,4% was alive by the end of 1997. For manufacturing firms, the figure is 33,0% (Table 2). As smaller firms have lower survival rates than larger ones, this difference can to a large degree be explained by the relatively large ratio of small firms in construction. In fact, for medium sized (5-24 employees) firms, the survival of construction firms is higher than for manufacturing firms (see table 3 in appendix C).

Table 2: Survival of construction and manufacturing¹² firms - 1981-97¹³

Year	Construction firms			Manufacturing firms		
	In business	% Survived	% change from previous year	In business	% Survived	% change from previous year
Start 1981	21285	100,0%		23795	100,0%	
End 1981	17650	82,9%	-17,1%	20857	87,7%	-12,3%
1982	15429	72,5%	-12,6%	18862	79,3%	-9,6%
1983	14126	66,4%	-8,4%	17481	73,5%	-7,3%
1984	13034	61,2%	-7,7%	16365	68,8%	-6,4%
1985	12198	57,3%	-6,4%	15346	64,5%	-6,2%
1986	11492	54,0%	-5,8%	14516	61,0%	-5,4%
1987	10833	50,9%	-5,7%	13561	57,0%	-6,6%
1988	10141	47,6%	-6,4%	12826	53,9%	-5,4%
1989	9468	44,5%	-6,6%	12002	50,4%	-6,4%
1990	8786	41,3%	-7,2%	11255	47,3%	-6,2%
1991	8206	38,6%	-6,6%	10605	44,6%	-5,8%
1992	7675	36,1%	-6,5%	9996	42,0%	-5,7%
1993	7210	33,9%	-6,1%	9477	39,8%	-5,2%
1994	6861	32,2%	-4,8%	8920	37,5%	-5,9%
1995	6555	30,8%	-4,5%	8552	35,9%	-4,1%
1996	6290	29,6%	-4,0%	8201	34,5%	-4,1%
1997	6052	28,4%	-3,8%	7857	33,0%	-4,2%

IDA-database. Own inquiries 2001.

It is surprising that the decrease of construction is almost constant in the period from, say, 1985 to 1993 taking into account that this period covers

¹² Nace 151000-410000.

¹³ A Mantel-Haenzel test shows that the difference in survival rates between manufacturing and construction is significant ($p < 0.0001$, $df=1$)

a clear upswing period (1985-1988) and downswing period (1988-1994). This supports the observation that construction firms are organised in a way that allows them to survive market fluctuations.

Nonetheless, to some degree the survival rates differ according to the initial year, assumedly due to the demand fluctuations. In table 3, the 1989 stock of construction and manufacturing firms are considered. After nine years (in 1997) 48,7% of the firms are left, whereas the same figure for 1981-89 is 44,5%. For manufacturing firms survival rates seems more stable (50,4% and 50,6% for 1981-89 and 1989-97 respectively).

Table 3: Survival of construction and manufacturing¹⁴ firms - 1989-97¹⁵

Year	Construction firms			Manufacturing firms		
	In business	Survived	% change from previous year	In business	Survived	% change from previous year
Start 1989	18601	100,0%		23392	100,0%	
End 1989	15909	85,5%	-14,5%	20496	87,6%	-12,4%
1990	14069	75,6%	-11,6%	18518	79,2%	-9,7%
1991	12780	68,7%	-9,2%	16989	72,6%	-8,3%
1992	11723	63,0%	-8,3%	15705	67,1%	-7,6%
1993	10911	58,7%	-6,9%	14608	62,4%	-7,0%
1994	10327	55,5%	-5,4%	13656	58,4%	-6,5%
1995	9846	52,9%	-4,7%	12995	55,6%	-4,8%
1996	9423	50,7%	-4,3%	12409	53,0%	-4,5%
1997	9052	48,7%	-3,9%	11845	50,6%	-4,5%

IDA-database. Own inquiries 2001.

Both table 2 and table 3 show that, unsurprisingly, “in the long run we are all dead”. However, seen from a (not to farsighted) firm point of view, the risk of a firm with whom one collaborates disappearing the following year, is not only higher in the construction sector, it is probably also more difficult to predict from past experience.

The closure of a firm can take different forms. As seen in Table 4, more than 80% of the closures for construction as well as for manufacturing

¹⁴ Nace 151000-410000.

¹⁵ A Mantel-Haenzel test shows that the difference in survival rates between manufacturing and construction is significant ($p < 0.0001$, $df=1$)

firms are final in the sense that the firm is not maintained by being (partially) transferred to another firm or into a company with no employees. If keeping up a relations with employees in a new firm or keeping up relations with a person working on his own is considered to be two sides of the same coin, in this respect, it is not particularly difficult to establish long-term working relations in construction.

Table 4: Identity of deceased firms 1981-98 (%)

	Construction firms	Manufacturing firms
Closed down	82,77	81,05
Absorbed by another firm ¹⁶	7,71	13,57
Changed to company (in same industry) without employees.	8,19	3,65
Other	1,33	1,73
Total	100	100

IDA-database. Own inquiries 2001.

Even if an important part of the adjustment in construction takes place by adjusting the number of firms, the fluctuations for firm size are also higher for construction compared with manufacturing firms. This becomes evident if we look at the distribution of the change of employment for each firm measured for the previous (Table 5) and subsequent (Table 6) year.

¹⁶ At least 30% and two employees transferred to new firm i.e. a new working-place).

Table 5: Distribution of change in employees - % growth for previous year

	1981	1989	1992	1995	1998	Average
Construction firms						
Quartile						
90%	167	180	171	168	162	169,6
75% (Q3)	111	120	119	122	120	118,4
50%	100	100	100	100	100	100
25% (Q1)	69	79	77	85	86	79,2
10%	50	50	50	58	63	54,2
Q3-Q1	42	41	42	37	34	39,2
90%-10%	117	130	121	110	99	115,4
Manufacturing firms						
Quartile						
90%	150	150	145	150	144	147,8
75% (Q3)	114	117	111	116	113	114,2
50%	100	100	100	100	100	100
25% (Q1)	83	88	85	91	90	87,4
10%	57	63	63	66	70	63,8
Q3-Q1	31	29	26	25	23	26,8
90%-10%	93	87	82	84	74	84

IDA-database. Own inquiries 2001.

Table 6: Distribution of change in employees - % growth for subsequent year

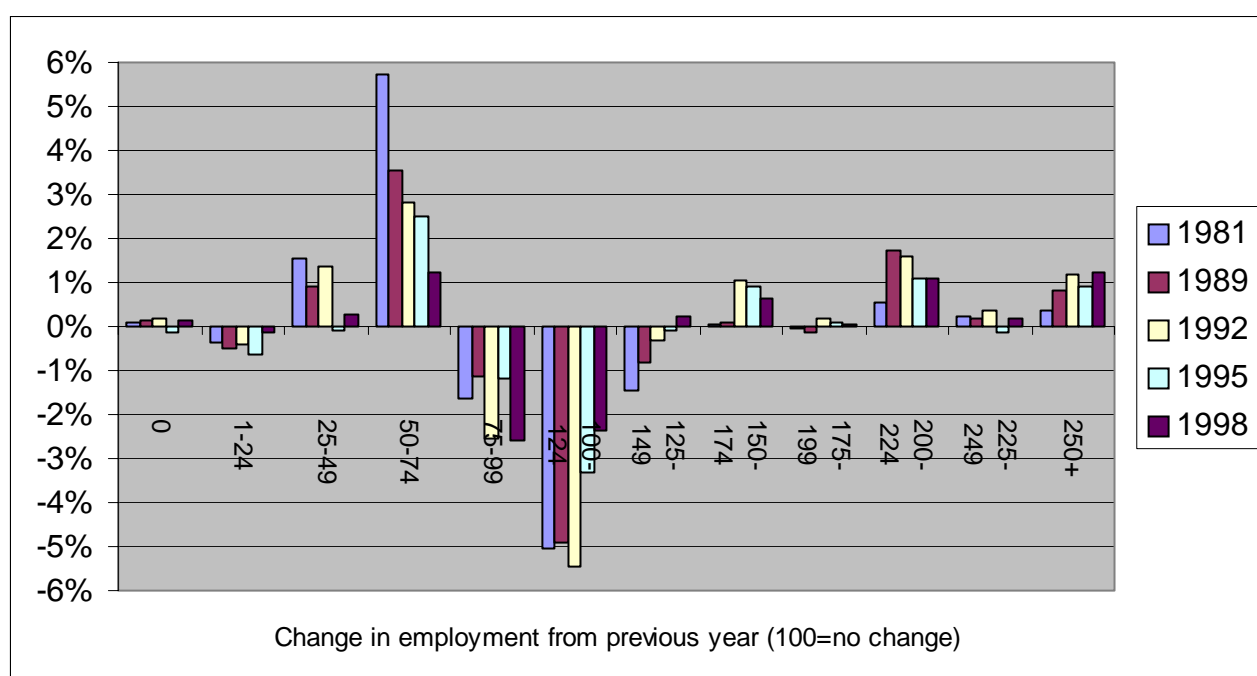
	1981	1989	1992	1995	Average
Construction firms					
Quartile					
90%	200	157	200	171	182
75% (Q3)	120	113	125	125	120,75
50%	100	100	100	100	100
25% (Q1)	75	75	80	88	79,5
10%	50	50	50	66	54
Q3-Q1	45	38	45	37	41,25
90%-10%	150	107	150	105	128
Manufacturing firms					
Quartile					
90%	150	150	141	144	146,25
75% (Q3)	116	115	109	112	113
50%	100	100	100	100	100
25% (Q1)	86	86	83	88	85,75
10%	61	63	60	66	62,5
Q3-Q1	30	29	26	24	27,25
90%-10%	89	87	81	78	83,75

IDA-database. Own inquiries 2001.

For all years, the pattern is the same. Construction firms face higher degrees of change in hiring and firing from one year to another. In average, one quarter of the manufacturing firms expand their size with 13% or more (the 75% quartile) and another quarter reduce their size with approximately 14% or more (the 25% quartile). In construction, change in number of employees is more profound, as the values of the 75% and 25% quartiles show an approximately 21% increase and decrease respectively. As also seen in the tables, in average for the four years, 10% of construction firms had to expand their number of full-time employees by 82% or more and similarly 10% of construction had to reduce their number of full-time employees to almost half (54%) or more (the same figures for manufacturing firms are 46,25% and 62,5%).

As illustrated in figure 10 the conclusion is also valid if the limited size of construction firms (as reported in table 1) is taken into account. In this figure, the distribution of change from the previous year in number of employees for individual firms has been compared for firms with 1-9 employees¹⁷. In all years, a relatively high proportion of manufacturing firms are concentrated around the value of 100 (i.e. with no change or little change in size), whereas construction firms are concentrated around low or high values (i.e. with a large reduction or increase in number of employees respectively).

Figure 10: Change in number of employees from previous year - distribution for construction firms minus distribution for manufacturing firms, firms with 1-9 employees



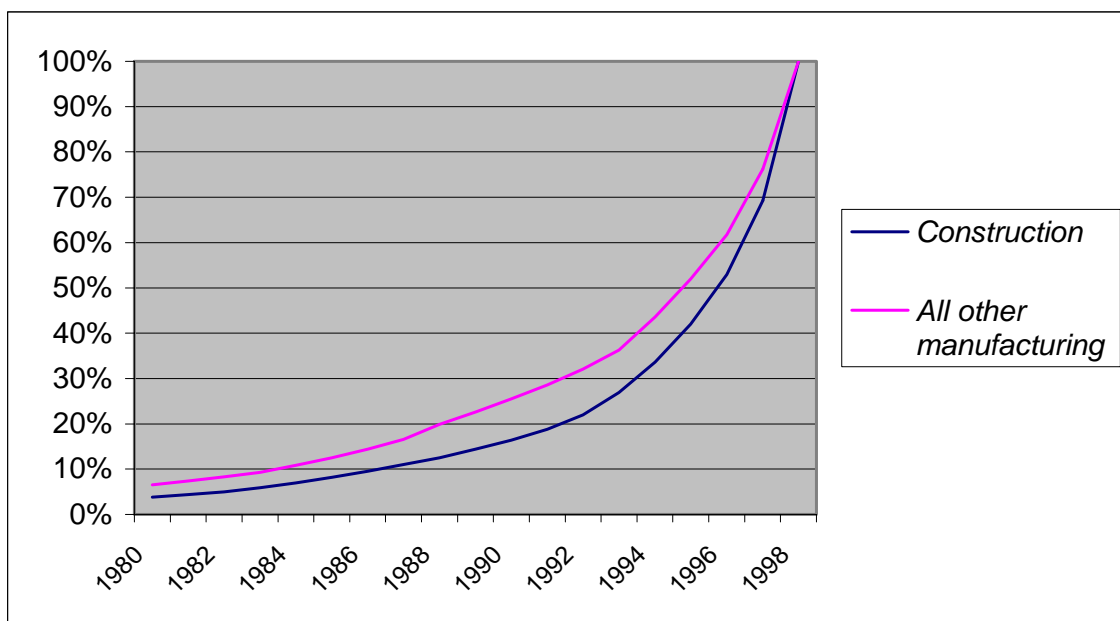
IDA-database. Own inquiries 2001.

¹⁷ This group is a not weighted average of the group of 1-4 and 5-9 employees irrespectively. As these two sub-groups did not differ much with respect to change in employees, for illustrative matters they have been joined.

5.4. Non-repetitiveness at the individual level

Naturally, change in number of employees is also reflected in the mobility of the employees. In spite of identical ages of individuals (in 1996 the average age was 37,83 and 38,64 for people in construction firms and all other sectors respectively (inquiries by Maskell 1998)) people have less seniority in construction firms as seen in figure 11 (the difference has been found to be significant with $p < 0,0001$, chi-square=6557, df=18).

Figure 11: Year of employment for employees in construction and manufacturing firms

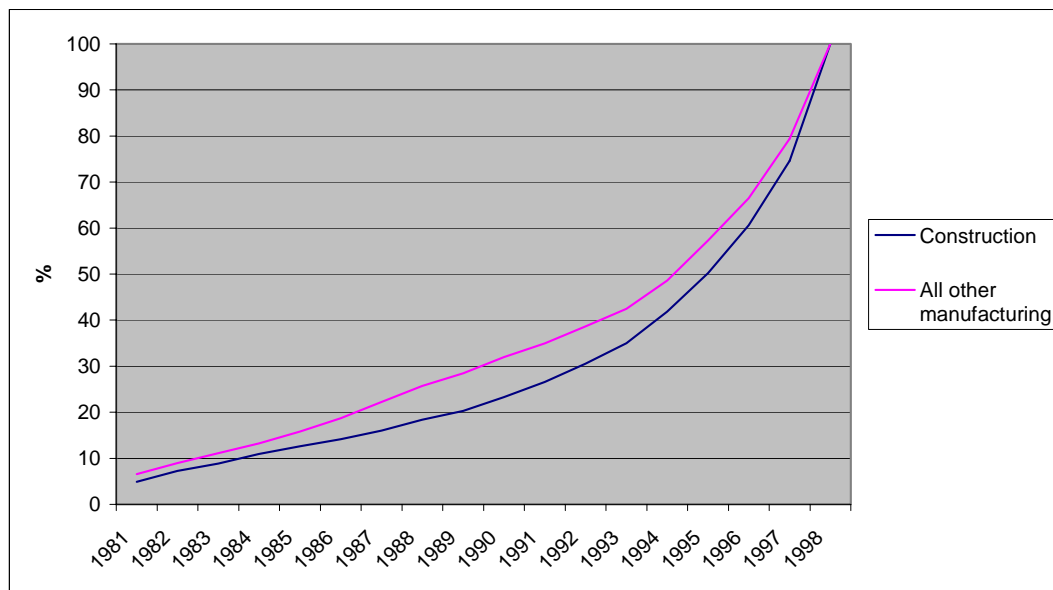


IDA-database. Own inquiries 2001.

If the difference in distribution of men and women is compensated for (women represent 10,07% of the employees in construction and 31,35% of the employees in manufacturing) by comparing only year of employment for men, the difference between construction and manufacturing is slightly greater (see figure 4 in appendix C). Furthermore, there are some regional variations in year of employment, but as this affects both construction and manufacturing (see figure 3 in appendix C), the *difference* for the investigated counties does not appear to be as clear as it was found for year of establishment of firms (even though some correspondence between these two measures would be expected).

To some degree, the findings on year of employment can be explained by the fact that construction firms in general are younger which obviously puts an upper limit for the seniority obtainable. However, if we in 1998 consider the time of employment for companies established in exactly 1981, construction workers still have a higher mobility than people employed in manufacturing firms (Figure 12).

Figure 12: Year of employment of individuals for firms established 1981 - Construction and manufacturing firms 1998



IDA-database. Own inquiries 2001.

The resulting flows of employees are shown in table 7. In total, approximately a third of the employees of the total workforce is entering and / or leaving a construction firm for each of the five registered years compared with only one out of four in manufacturing.

Table 7: People entering a construction firm in previous year or leaving a construction firm the subsequent year¹⁸

Construction	1981	%	1989	%	1992	%	1995	%	1998	%
Entering	38693	32,2%	47402	33,0%	36020	31,8%	42694	33,3%	42349	31,2%
Leaving	43669	36,3%	50099	34,9%	39868	35,2%	38522	30,1%		
No. of employees	120267		143463		113151		128050		135563	
Manufacturing										
Entering	107029	24,9%	126795	26,9%	107062	24,0%	118375	26,6%	108517	24,3%
Leaving	104878	24,4%	128073	27,1%	117731	26,4%	115327	25,9%		
No. of employees	429114		472072		446732		445617		445787	

IDA-database. Own inquiries 2001.

5.5. Indications of organisation in trades, craft production and trilateral coordination

It is noteworthy, in table 7, that the level of people entering or leaving construction firms is higher than manufacturing and approximately at the same level for all of the five observed years, even though some of these years represent upswings and others downswings. This suggests that the high mobility is not a direct response to market fluctuations. An alternative explanation is that the mobility is caused by organisation in trades. As argued in chapter 2, groups (=trades) of people with homogenous capabilities can be a way to reduce on coordination costs in environments where external changes do not favour long-lasting relations between specific persons or firms. As people belonging to the same trade do not specialise, they can enter a new firm with low switching costs (clearly exemplified in the case study in the next chapter). Thus, the high mobility within construction observed in table 7 could be caused by the trade organisation. That mobility in construction

¹⁸ For instance in 1981, 108127 persons were employed in a construction company. In 1980, 40040 of these people were not found in the same company and similarly, in 1982, 45885 were not found in the same company as in 1981. The movement can be within or in and out of the construction sector.

is not limited to any particular educational group further indicates the pervasiveness of the trade organisation.¹⁹

The balance between in- and outflow of the sector is rather obviously affected by whether the construction sector is in a period of expansion or not. The adjustment of the total workforce in construction is made feasible due to a dense exchange of labour located outside the sector. In 1995, approximately 40% of the people leaving or entering a construction firm was going to or coming from a firm outside the construction sector. In manufacturing the figure is approximately 45%.²⁰ Again, the pattern does not seem to be highly influenced by educational backgrounds: both skilled and unskilled people leave and enter the construction sector. Consequently, a somewhat surprisingly high number of people educated as craftsmen are employed in non-constructing firms (34% for bricklayers, 53% for carpenters, 50% for plumbers, 41% for painters, and 60% for electricians).

Apparently, a craftsman education has a rather wide applicability. With this in mind, the low degree of penetration of people with one craftsman education into different types of construction firms is remarkable. Or put differently, the degree to which construction firms mix professionals is very low (table 8).²¹ In fact, it is more likely to find an auto-mechanic than a plumber in a carpentry-firm.

¹⁹ It could be imagined that the high mobility in construction was caused by a small group of extremely mobile workers, filling in the gaps in manpower, whereas the large majority of people working in the sector were as fixed as in other industries. However, at least concerning educational level, the mobility does not appear to be limited to a sub-group: unskilled people are only slightly more mobile than skilled workers. In 1998 people with public school or less represent 31% of the workforce, which fits rather well with their share of people leaving and entering a construction firm (33% and 35% respectively).

²⁰ The data on destination industry are rather incomplete (in 1995 not known for 37,5% for the people leaving manufacturing and 28,1% of the people leaving construction. This residual group has been distributed to the different industries according to the respective size of the known values (in other words, it is assumed, that the errors are distributed randomly across the industries).

²¹ Table 8 was constructed in order to see, if there were any systematic patterns in the companies that survive. It was hoped, that the figure would illustrate, that construction companies integrating several educational backgrounds (which could be seen as a proxy for firms integrating a string of activities into a single firms) performed poorly compared with “pure” (with respect to education) firms. However, for both surviving and deceased firms non-pure firms are very rare, and hence, it was not possible to investigate this hypothesis by this approach.

**Table 8: Educational background of employees and sector employment
- 1981(bold letters = match between education and employment)**

		Surviving firms (1981-98)				Deceased firms (1981-98)			
		<i>Industry:</i> Bricklayers	Carpenters	Plumbers	Electricians	Bricklayers	Carpenters	Plumbers	Electricians
<i>Domain of education</i>	<i>Education:</i>								
	Public school or less	37,47%	28,14%	31,59%	34,28% ²²	34,25%	27,05%	30,10%	31,66%
Bricklaying	Bricklayer	46,77%	0,88%	0,06%	0,00%	45,97%	0,72%	0,06%	0,03%
Carpentry	Carpent.	2,06%	44,76%	0,19%	0,06%	2,78%	43,69%	0,28%	0,10%
	Joiner	0,15%	11,85%	0,00%	0,00%	0,56%	12,79%	0,06%	0,00%
	Cabinet m	0,11%	1,85%	0,00%	0,00%	0,09%	2,04%	0,00%	0,00%
Plumbing	Plumb. 1	0,07%	0,04%	13,32%	0,03%	0,08%	0,03%	10,91%	0,00%
	Plumb. 2	0,04%	0,00%	14,28%	0,00%	0,06%	0,01%	14,70%	0,00%
	Plumb. tech	0,15%	0,00%	9,55%	0,00%	0,00%	0,00%	7,64%	0,00%
	Smith 1	0,04%	0,02%	2,56%	0,00%	0,11%	0,03%	11,06%	0,10%
	Smith 2	0,15%	0,00%	3,16%	0,03%	0,02%	0,00%	1,85%	0,00%
	Smith 3	0,00%	0,00%	5,01%	0,03%	0,06%	0,01%	3,05%	0,03%
Electricity	Electric.	0,07%	0,04%	0,35%	32,47%	0,17%	0,10%	0,59%	29,14%
	El. techn.	0,04%	0,04%	0,38%	21,89%	0,08%	0,01%	0,43%	25,56%
Other	Building tech	0,59%	1,03%	0,06%	0,00%	0,56%	0,89%	0,06%	0,00%
	Mechanic	0,22%	0,06%	2,65%	0,06%	0,32%	0,10%	3,08%	0,06%
	Auto mec	0,37%	0,21%	0,57%	0,09%	0,45%	0,18%	0,74%	0,03%
	Other	11,72%	11,07%	16,26%	11,04%	14,44%	12,33%	15,40%	13,28%
In total		100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%

Source: IDA database, own inquiries 2001.

As seen in the table, approximately 85% of the workforce within the four trades is either non-skilled or skilled within an area corresponding to the industry (=NACE) code of the firm in which they are employed (carpenters works in carpentry-firms etc.). Only a very small portion of the skilled workers work out of their domain: 2,9% of the workforce in

²² Almost all electricians in this category have 10 years of public school training, whereas for the other trades 7 years of public school training is the most common. Hence, electricians are more educated than the way of classifying education used here would suggest.

the surviving bricklaying firms are educated within other trades (within carpentry, plumbing or electricity). For carpentry, plumbing and electricity firms, the figures are as low as 1%, 1% and 0,16% respectively.

Further, the homogeneity of firms concerning education could be seen as a result of a *trade organisation*. This attribute of construction is also confirmed by the homogeneity of the education of the employers (table 9).

Table 9: Educational background of employers and sector employment (%) - 1998 (bold letters = match between education and employment)

Education	Industry	All employers outside construction	General contractors	Bricklayers	Electricians	Plumbers	Carpenters	Painters	Engineers	Architect	Total number of persons
Public school oress		25,99	39,84	8,54	2,89	7,24	6,96	8,64	1,53	3,82	18197
Highschool		4,22	1,79	0,31	0,36	0,57	0,5	0,84	0,76	0,96	2839
Bricklayer		0,35	8,46	78,6	0	0	0,13	0,46	0,76	0	29137
Carpenter		1,32	9,27	1,68	0	0	78,3	0,19	0	0,64	1344
Plumber		0,22	0,98	0	0,12	27,33	0	0,09	0	0	2892
Smith		1,48	2,28	0,23	0,6	25,52	0,42	0	0,76	0	461
Painter		0,33	0,49	0	0	0	0,08	80	0	0	1090
Electrician		0,64	1,63	0,15	11,1	1,43	0,21	0,09	0	0	552
Other basic vocational courses		43,12	20,81 ²³	2,52	3,25	10,38 ²⁴	4,69	5,67	4,58	3,83	1298
Supplementary vocational courses		3,01	2,93	2,44	77,6 ²⁵	23,62 ²⁶	3,35	1,67	4,58	5,73	3059
Diploma		4,36	7,64	4,04	3,37	2,38	3,44	0,65	63,4	24,2	3290
Bachelor		0,4	0	0,08	0	0	0,13	0	0	0	268
Master		11,82	0,98	0,15	0,12	0,1	0,29	0,09	20,6	58	7994
Doctoral / Ph.D. degree		0,08	0	0	0	0	0	0	0	0,32	54
Not known		2,66	2,93	1,3	0,6	1,43	1,55	1,58	3,05	2,55	1893
Total		100	100,03	100	100	100	100	100	100	100	
Total number of firms		65668	615	1311	830	1050	2386	1076	131	314	

Source: IDA-database. Own inquiries 2001.

²³ This group consists of people with a wide range of educations. Motor mechanic is the most common (25 persons), 11 persons are sales assistants and 10 persons have an education as a farmer ("Grønt bevis"). No other educational codes can account for 10 persons or more.

²⁴ The majority of this group are mechanics (57 persons) or motor mechanic (16 persons).

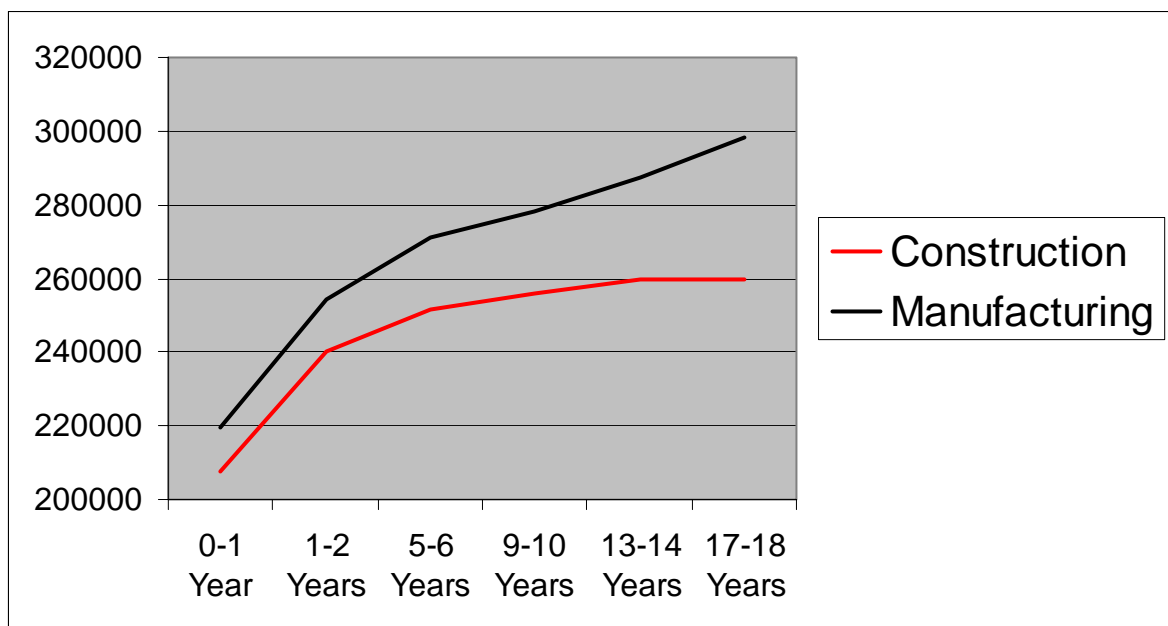
²⁵ This group consists solely of electricians (educational code 40592425).

²⁶ This group consists solely of educations related directly to plumbing: "vvs-tekniker" (107 persons) and "gas, vand og sanitetsmester" (126 persons).

As seen, there is a major overlap between industry and educational profile in the sense that the employer in the bricklaying firm is educated as a bricklayer etc. Only the general contractors have a diversified educational background, possibly suggesting that this group consists of firms doing casual and in technical terms not very difficult work (corresponding to the group “public school or less” and “other basic vocational courses”) and a group of firms that have developed from being either bricklayers or carpenters into the role of main or design and build contractors.

To recall chapter 2, the *raison d'être* of a trade organisation is to replace repetition between specific persons and firms with repetition at a more aggregate level, i.e. between groups (=trades) of people and firms with identical capabilities. As people within the same group should not be different, it would be expected that these persons to a lesser degree obtain specialised capabilities over time than people working in industries facing more stable external conditions. An indication of low level of specialisation over time would be that the impact of seniority on income is relatively low. This expectation seems to fit well with figure 13.

Figure 13: Seniority within the firm and average annual income (DKK) of full-time male employees with a basic vocational course as highest degree – construction and manufacturing 1998



IDA-database. Own inquiries 2001.

For employees with 0-1 year of seniority the annual income is only 5% higher in manufacturing than in construction. However, as the increase in salary of employees in construction evens out, with 17-18 years of employment the differences has amounted to 15%.

The data also gives signs of the existence of *craft production*. As discussed in chapter 2 and 3, in case of low repetition in activities (for instance caused by changes in external conditions), skilled labour that act as local information processors would be expected to be common due to their ability to handle a wide range of different situations (whereas in more stable settings information is often more cheaply handled by standards for inputs or working procedures). Thus, in combination with apparently widely applicable skills as discussed previously, the low level of unskilled workers found in construction could be interpreted as a sign of *craft production* (table 10).

Table 10: Educational background of full time employees in construction and in total 1998

Education (highest degree completed)	Producers of building materials	Contractors	Engineers and Architects	Full time employees in all industries
Public school	45,4%	30,5%	9,8%	35,2%
High School	3,2%	2,7%	6,0%	7,7%
Basic Vocational Courses	37,5%	55,9%	23,8%	30,4%
Supplementary Vocational Courses	4,0%	5,0%	7,4%	3,5%
Diploma	6,0%	3,9%	30,7%	9,1%
Bacehelor	0,4%	0,2%	1,4%	0,8%
Master	1,4%	0,6%	18,0%	3,9%
Doctoral / Ph.D. degree	0,1%	0,0%	1,2%	0,1%
Not known	2,0%	1,3%	1,7%	8,4%
In total	100,0%	100,0%	100,0%	100,0%

IDA-database. Own inquiries 2001.

As it appears in table 10, only a few academics are employed in the building materials firms, almost no academics are found in contracting firms whereas the concentration of academia is high in firms of architects and engineers (this in turn implies a level of academia that is about half compared with the level for all industries, as the majority of employees are employed in contracting firms (145961 persons compared with 9580 and 16589 persons in building materials producing firms and

engineering and architectural firms respectively)). In accordance with the finding in table 9, including the education of employers does not alter the level of academia found in contracting firms (but does change the average for all industries, as employers on average are more educated than employees, see table 1 in Appendix C).

On one hand this concentration of academics in firms of architects and engineers can give rise to benefits from specialisation. On the other, it is often argued that the presence of academia enhances firms capacity to absorb knowledge (Knudsen 2001). Assumedly, this would urge firms to employ some amount of academic staff. However, the observed concentration of academics may be accounted for by the widespread use of third party coordinators, i.e. firms (e.g. engineers and architects) specialised in the demanding job of coordinating construction activities. As argued in the theoretical part, high levels of external change is likely to favour such a separation between production and coordination. A generally low level of repetition in collaboration between specific contracting firms and specific firms of architects and engineers may also explain the limited co-localisation (in geographical terms) of these firms (see Table 2 in appendix C).

5.6. Summary on non-repetitiveness on the level of the sector, the firm and the individual

This chapter has provided statistical information on overall changes in the market for construction products and made likely how these changes are related to changes at the level of the firm and individual.

At the sector level it was shown that:

- Different segments of the construction markets “co-oscillates”; e.g. when demand for one type of construction activities decreases, so does demand for other types of construction activities.
- Accordingly, overall demand in construction fluctuates considerably compared with most other sectors. Furthermore, periods of downswings are followed quickly by periods of upswings and visa versa.

In combination with a very limited export, this makes it difficult for construction firms to keep up a steady level of production. This seems to be consistent with the data found at the level of firms and individuals (compared with manufacturing firms):

- High turnover in construction firms. Many construction firms go out of business in periods of recession (the survival rate is low) and in particular many new firms enter in periods of prosperity. Thus, construction firms are generally young.
- Partly due to this, partly due to a limited growth in size of existing firms, construction firms are small with respect to number of employees.
- Construction firms make more radical adjustment in number of employees.
- Accordingly, the mobility of employees is high in construction. Roughly one third of employees are not employed in the same firm the year before and one third are not employed in same firm the year after. Thus, seniority is low in construction.

Other things being equal, these characteristics lower repetition in working constellations from one building project to another. Repeated interaction *between* specific firms is limited due to the high turnover in

firms and due to the many small firms. High mobility of employees limits interaction *within* the firm.

The data have also given some indications of how construction – perhaps as a response to limited benefits from repeated sequences of activities due to changes in overall demand - is organised. And in this way, the chapter provides some initial answers to in particular research question A and B relating to the division of labour and the role of the firm.

Mainly skilled labour is used in construction. That roughly half of the people educated as craftsmen are employed outside the construction sector, suggests the wide applicability of these skills. It is conceivable that these observations are signs of the use of *craft production* in construction.

A second set of observations potentially relates to the existence of *trade organisation* in construction. Firstly, it has been found that employees are grouped together according to their skills: Carpenters are employed with carpenters, plumbers with plumbers etc. The homogeneity of skills is also mirrored with respect to the educational profile of employers. The isomorphism of people working within the same trade can also explain the high mobility of both skilled and unskilled labour in construction as well as why seniority is not very important with respect to earned income.

Finally, concentration of academics in firms of architects and engineers and the minor growth in size of construction firms potentially have to do with the existence of *bilateral and trilateral coordination*.

Even though the present chapter in this way has made the existence of craft production, trade organisation and use of bilateral and trilateral coordination likely, their existence has not been directly identified or necessarily been well understood. Thus, in the following chapter these ways of handling low repetition are further explored and discussed in an empirical analysis of roof-construction targeted exactly at the research questions.

Chapter 6 – Coordination practices in the construction process

6.1 Overview of the chapter

By means of a case study, this analytical chapter addresses the research questions on the division of labour, the organisation of coordination within and between firms, and the use of coordination modes in construction. Hence, the main part of this chapter is devoted to describing and analysing, how coordination is organised and executed in the construction of a roof on a multiunit residential house being build in Copenhagen, Denmark.

A brief introduction to the actors and phases of house construction is offered in appendix A. For readers that are not familiar with construction, I will recommend to read the appendix as an “appetizer” before the empirical inquiry into the research questions. In the previous chapter it was illustrated how non-repetitiveness at the macro level of markets influences firms and individuals. Appendix A points out the non-repetitiveness related to the micro level of each building project, for instance (a) specifications of the client (or the architect), (b) physical variations on the site, (c) differences in many actors “surrounding” the building project (local authorities, public suppliers and neighbours).

The low level of repetition at the macro level created by unstable markets consequently interacts with the low level of repetition at the micro level related to the specifics of each building project. The combined impact that these two sources to non-repetitiveness have on coordination is considered in the case study on roof construction (Section 6.2). The findings of the case study are organised according to the main concepts outlined in the research issues: the division of labour (6.2.1), coordination modes (6.2.2), the organisation of coordination (6.2.3) and the information involved in coordination (6.2.4, 6.2.5 and 6.2.6).

The main thread of the argument developed throughout this chapter is the importance of (lack of) repetition on the way coordination is organised and structured. The chapter closes with an illustrative example of how coordination is organised and structured in a more

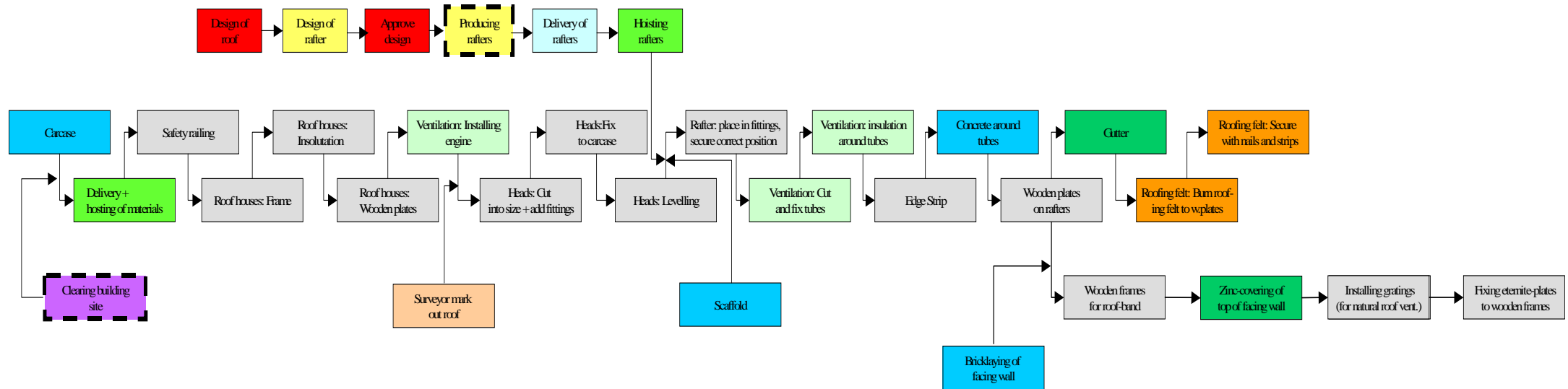
stable setting. This is done by briefly considering a case study on sofa production (section 6.3).

6.2 *The organisation and coordination of roof construction*

6.2.1 Specialisation and the division of labour in roof construction

As a starting point, consider the production activities involved in producing the roof as outlined in Figure 2.

Figure 2: Activities involved in roof production



In the figure, each box represents an activity, that is one continuous working process (resulting in tangible or intangible transformation of an input), as conducted by a single person using the same tool(s) or equipment (see also chapter 4 on method). Boxes with dotted lines may include more than one activity. Each colour represents a firm.

Firms and individuals involved in production

Evidently, many different firms are involved directly in the process of constructing the roof. More precisely, there are seven of them: producers of the carcass, haulage contractors, carpenters, the surveyor, ventilation contractors, plumbers (making the gutter), and roofing felt contractors. Accordingly, each firm only carries out a limited part of the activities involved in the value chain of roof production. Most of the firms involved in roof production also work on other parts of the building; the roofing felt contractor was in fact the only firm that solely worked on the roof (I shall elaborate on this particular example later on). Within each firm, the activities are carried out by a rather limited group of people; a group of mostly four to five carpenters carries out all the carpentry activities involved in constructing the house. On the roof, two carpenters performed most of the work with additional support from two other carpenters. The two former carpenters worked on multiple other parts of the project, not only before and after, but also while the roof was constructed.

The observation that each firm and each individual works on multiple parts of the building, is also found at a refurbishment project in Odense (box 2). As seen in the first table, most of the seven carpenters attached to this project use their time on multiple parts of the building (even though the single parts of the building entail sufficient work to keep a single person employed for longer time). At the firm level, the last table in box 2 suggests that a low level of specialisation according to particular parts of the building is general to all five trades (with electricians as the most radical exception, as they only work on 3 out of the 7 parts the building for analytical purposes was decomposed into).

Thus, both at the level of firms and individuals, there appear to be a very limited, if any, specialisation with respect to building parts. As the craftsmen vary their position in the value chain (i.e. in the part of the

house they are working on), repetition in activities is not obtained by completely identical input and output.

However, this does not however exclude the possibility of specialisation along other lines, more precisely specialisation in the tools and working procedures used. In fact, it could be the case that each firm and each individual shifts their position in the value chain in order to achieve repetition in tools and working procedures.

The traditional way of organising trades according to materials (see Appendix A) can be interpreted in favour of specialisation of this kind. For example, by working on different parts of the building, the carpenters can always use their experience and equipment related to woodmaterials. In this interpretation, trades are explained by lower production costs due to repetition in activities.

Box 2: Specialisation in construction - a time study of refurbishment

A second set of evidence on the characteristics of the division of labour and specialisation in construction can be derived from the time study of a refurbishment project in Odense (in Denmark). Based on the data (Bertelsen (1996, 2002) whom I thank for access) it can, among other things, be calculated how each craftsman (including apprentices) from the different trades spent his time on different parts of the building. Only the results from the carpenters are shown in the following table, but these reflect the general pattern for all trades:

	Roof	Facades	Staircases	Bath/WC	Kitchen	Heating	Other	Building site	In total
Carpenter 1	19%	0%	25%	1%	42%	0%	8%	0%	100%
Carpenter 2	86%	0%	10%	0%	3%	0%	0%	0%	100%
Carpenter 3	41%	1%	0%	6%	40%	0%	12%	0%	100%
Carpenter 4]	4%	0%	0%	0%	96%	0%	0%	0%	100%
Carpenter 5	26%	42%	0%	0%	32%	0%	0%	0%	100%
Carpenter 6	31%	44%	0%	0%	25%	0%	0%	0%	100%
Carpenter 7	76%	0%	0%	10%	14%	0%	0%	0%	100%
Carpenters in total	48%	8%	6%	3%	31%	0%	4%	0%	100%

Apparently, it is very rare for skilled craftsmen to concentrate on only part of the building, which supports the view that craftsmen are not very specialised – at least not concerning specific parts of the building. However, the picture is not entirely unambiguous. As summarised in the next table – showing number of contracts (defined for different parts of the building) per trade and distribution of each skilled craftsman and subcontractor according to contracts - subcontractors to the subcontractors concentrate mainly on one part of the building.

(Continues)

Box 2: Specialisation in construction. Continued. .

	Carcass	Carpenters	Painters	Plumbers	Electricians
Number of relevant contracts	5	6	6	5	5
Number of contracts worked on by each skilled craftsman (avg.)	3,17	3,4	3,25	1,67	3
Number of contracts worked on by each subcontractor (avg.)	1	1,2	-	1,76	-

Thus, it appears that a dual structure among workers on the building site may exist: the unspecialised subcontractors performing activities on different parts of the building and specialised subcontractors working on specific parts. In this refurbishment case, the latter group only accounted for 13% of the total number of man-hours spent.

But perhaps - one could argue with reference to the smithian idea that “the division of labour is limited by the extent of the market “ (1970) - the low division of labour is simply a result of the small size of this particular case. In this explanation, craftsmen work on many different parts of the building simply because the man-hours needed to complete one part are not sufficient to keep them employed full time. If this were the case we would only expect a few persons from each trade to work on a single part of the building. As seen in the next table - showing the number of people from each trade working on different parts of the building - this is clearly not so; craftsmen do work on many different parts of the building in spite of the fact that the single part of the building requires many man-hours to be completed. Of course this does not exclude the Smithian idea of a division of labour (for instance specialisation could be according to specific tools or materials used on various parts of the building), but does however signify, that such a division of labour at least is not done according to parts of the building.

No of people in different parts of the building								
	Roof	Facades	Staircases	Bath/WC	Kitchen	Heating	Other	Building site
Carcass	8	7	2	5	5	0	0	0
Carpenters	10	4	5	3	10	0	4	0
Painters	0	1	4	6	4	1	4	0
Plumbers	3	0	0	3	1	6	2	0
Electricians	0	0	0	3	4	0	6	3
Total	21	12	11	20	24	7	16	3

The number of people involved in each building part in this rather small refurbishment case is impressive. The kitchens are the most crowded with no less than 24 persons involved, but roofing and bathrooms are also “heavyweighters” in this respect. Taking the limited size of these areas into consideration, the sole number of people involved gives reason to expect problems of coordinating access to the objects.

The dynamics of trades

However, it may not always be obvious for the people involved in construction whether new materials are more closely related to one trade or another. The carpenters from the case study gave the following example: when partition walls made of gypsum were introduced in the post-war period, it was not clear whether they should be erected by bricklayers or carpenters, as gypsum in this context was a new material that could be handled both by the carpenters (who made the wooden structure in the old type of board partition walls) and by the bricklayers (who did the subsequent plastering in board partition walls). In this particular case it was by union arbitration settled that partition walls is a carpentry-job.

One may wonder why partition walls solely become a carpentry job. If both carpenters and bricklayers are equally qualified to do this job in the outset, craftsmen from both trades (or in order to ensure repetition, *some* craftsmen from both trades) might do this job.

A possible reason for why one type of activity is not carried out by multiple trades, has to do with coordination costs (and not production costs). In the case that an activity can be performed by two or more trades, the parties involved in construction would have to exchange information in order to find out who does it. Assigning an activity once and for all to a particular trade renders this information superfluous.

A further benefit of assigning an activity to a particular trade is that it will be carried out by people with identical backgrounds. For instance, all persons working in the carpentry firm were educated as carpenters. This observation reflects the more general observation from chapter 5, that trades, and in turn firms, consist of groups of people with almost identical educational background. A possible benefit of this way of organising is that a person in the value chain of house production knows more or less what to expect from the previous person, even without knowing the specific firm or person.¹

¹ The interaction between persons without prior knowledge of each other is further promoted by the use of “trade uniforms” (provided by the employers): carpenters are dressed in white trousers and jackets; plumbers wear blue overalls and so forth.

The existence of a trade organisation – in which there generally is specialisation between the trades but not within the trades – is also reflected in the answers given to the part of the questionnaire relating to specialisation. Here the carpenters replied, that they believed that all carpenters in their company, and in other companies, would be as good as himself at performing the activity in question. In the same way “particular knowledge” is never stated as a criterion for how work is delegated. Rather, it is delegated according to health reasons (some work is tough and is left to younger personnel), personal relations (some persons have worked together previously), and some degree of coincidence. As no one is assigned for a particular job in the outset, delegation and redelegation of manpower takes place frequently. Usually, the carpenters are instructed by the foreman during the morning break: “today” or “this week we have to do so and so” and then without much discussion they are assigned to the different jobs.²

Cliques

The category “personal relations” contains an interesting story. It turned out that the carpenters in the case study often establish cliques which enables them to maintain the same working relation from one project to another and, more remarkably, from one firm to another. One such example was the group of four carpenters that worked on the case project during the first half of the project (the replacement of carpenters is described later in this section). They and two additional carpenters had worked together on two larger projects previously. They preferred to work together since they knew each other beforehand and knew that they get on well, which in turn made it easier for them to plan their work. Firstly, this gives them a better piece-rate pay. Secondly, they find that it is more fun to work on large sections of a project than doing a bit of work here and there, or doing service calls, as a person working on his own is often forced to do. One of the reasons for their dissatisfaction with the case project was that they were not allowed to plan their work

² This practice was also observed during the first working day of the second team of carpenters (described below). The short time spent on allocating specific persons to an activity favours the view that allocation is done according to widely applicable skills of the carpenters, and not by advance knowledge of the speciality of the respective carpenters.

themselves. Moreover, the clique originally consisted of six persons but the management of the firm could only find work for four of them on this project. Consequently, the four carpenters jointly decided to leave the company in order to work on a building project large enough to employ all six of them and, they hoped, with more scope for planning the work themselves. In general, they had no major problems finding projects that were large enough to accommodate all of them, as “there are many big projects going on at the moment”.³

A smaller clique was formed by the two experienced carpenters, who together with three other carpenters replaced the first clique midway through the project. The two carpenters were both educated in the beginning of the 1960s and worked together for many years until, at the end of 1980s, one of them was employed as responsible for erecting noise reducing screens as part of large road project. However, when this project was completed a decade later, the two carpenters started to work together again. According to the first four carpenters, these cliques frequently occur in carpentry as well as the other major trades. This conclusion is supported by a field study of site organisation in two Danish building projects conducted in the mid 1970s (Kristian Kreiner 1976). On the other hand, statistical inquiries in the IDA-database - made exactly for assessing the extent of these cliques - points towards the fact that they are not very dominant both in absolute terms and compared with manufacturing (see box 3).

As this illustrates, although carpenters can and do work together in different constellations, the carpenters of the case-study believes that there are benefits from repeating the same personal relations within the trade. These benefits are not related to producing a particular output (as this is described by the specifications of the architect) or a particular input (as this is provided by the outcome of the previous activities and the materials delivered by the foreman or clerk of works). Rather, the benefits have to do with a higher speed (or perhaps more fun) in their work, as the carpenters can easily split up a job into more narrowly defined activities based on experience. Besides economising on decision costs of who should do what, this also allows some (rather limited)

³ The four carpenters were rather young and had in average 10 years' experience. Thus, they have mainly been employed during booming periods.

specialisation in working tools. For instance, in the test study on installment of windows, it was observed how one of the carpenters had gained experience in using a lift in previous projects, and hence was also assigned to this job in this project. The other carpenters did not consider him to be the only one who could do this job – but he was a bit faster.

Homogenous capabilities and mobility

However, the (rather limited existence) of cliques does not challenge the overall picture of a limited division of labour within the trade. Besides, for the reasons listed above, the limited division is reflected in the answer given by the carpenters concerning what they considered it was important to be good at in order to perform a particular activity. Here, very general capabilities are pointed at as important. As one of the most experienced carpenters said:

“The basic principles are always the same. You have to ensure that things are in plumb, in level and at the right angel. It always goes back to the same things you need to be good at to make a playhouse for you children. For the same reason, besides being good at this, we do not transfer any particular skills from one building site to another.”

Confronted with the question of how these capabilities differed from the capabilities of other trades, the carpenters answered that these capabilities were also fundamental to other trades. However, if other trades should do carpentry work, it would undoubtedly take them much longer time. As this illustrates, due to their education and their experience, carpenters do develop particular capabilities.⁴

⁴ As the quote also illustrates, the particular knowledge of a group of professionals is difficult to probe into by interviews, as the professionals tend to take their competencies for granted. Probably this tendency is enforced in a system like construction, where a profession is rather stable over time and only to a limited degree is confronted with close cooperation with other professional groups.

Box 3: Cliques - a non-firm dependent division of labour?

Inspired by the case study, the commonness of cliques in construction was investigated by the IDA-data base. A clique was defined as two persons or more, who in the initial year (for instance November 1995) were all employed in one firm and who in the next year of registration (for instance, November 1998) were also employed together, but in a different firm. The results are shown in the following table.

Cliques 1995-1998	Construction (Nace code in initial year)			Manufacturing (Nace code in initial year)		
	No of persons	Persons as % of total workforce 1998	Persons as % of people changing job 1995-98	No of persons	Persons as % of total workforce 1998	Persons as % of people changing job 1995-98
2-person cliques	3290	2,4%	4,1%	7508	1,7%	3,5%
3-person cliques	1182	0,9%	1,5%	3099	0,7%	1,4%
4-person cliques	544	0,4%	0,7%	1916	0,4%	0,9%
5-person cliques	415	0,3%	0,5%	1245	0,3%	0,6%
6-person cliques	330	0,2%	0,4%	972	0,2%	0,5%
7-person cliques	266	0,2%	0,3%	700	0,2%	0,3%
8-person cliques	160	0,1%	0,2%	568	0,1%	0,3%
9-person cliques	189	0,1%	0,2%	540	0,1%	0,3%
10-person cliques	150	0,1%	0,2%	460	0,1%	0,2%
10+ cliques	2486	1,8%	3,1%	15605	3,5%	7,3%
Total	9012	6,5%	11,2%	32613	7,3%	15,2%

In 1995-1998, cliques represent 6,5% and 7,3% of the total 1998 workforce in construction and manufacturing, respectively. Compared with the actual number of persons changing firm within the period (estimated by information on year of employment provided in chapter 5), the level of cliques is even smaller in construction than in manufacturing (11,2% and 15,2% respectively)).

This way of measuring cliques also includes persons, who incidentally both were in firm A and B in the first and second period respectively, but who did not work together (and in this way do not represent a clique in the sense of people working closely together). The chance that such coincidental co-movements exist is increased with the size of the two firms. In order to control for that, the following table shows the number of persons moving in cliques for companies with 2-9 fulltime employees (as cliques are defined by employment in November the respective year and not by fulltime employment, it is possible for these firms to have a 10-person clique as seen for manufacturing).

(Continues)

Box 3: Cliques – a non-firm dependent division of labour? Continued.

Cliques 1992-1995	Construction		Manufacturing	
Firms with 2-9 full time employees	No of persons	Persons as % of total workforce 1995	No of persons	Persons as % of total workforce 1995
2-person cliques	666	1,3%	630	1,0%
3-person cliques	243	0,5%	309	0,5%
4-person cliques	144	0,3%	228	0,4%
5-person cliques	65	0,1%	160	0,3%
6-person cliques	90	0,2%	108	0,2%
7-person cliques	28	0,1%	77	0,1%
8-person cliques	8	0,0%	48	0,1%
9-person cliques	18	0,0%	9	0,0%
10-person cliques	0	0,0%	10	0,0%
personer i klier på 10+	34	0,1%	27	0,0%
Total	1296	2,6%	1606	2,6%

Adjusting for firm size, cliques are at the same level in construction and manufacturing measured as percentage of the total workforce. However, taking mobility into account, it will most likely still be lower in construction than in manufacturing. Thus, it does not seem that this non-firm specific way of having a division of labour is particular dominant in construction.

The statistical data presented in chapter 5 showed the homogeneity of educational background and the high mobility of workers between firms belonging to the same trade. The case study confirms and fleshes out these indicators of low specialisations among firms of the same trade. All persons working within the carpentry firm were educated as carpenters and shifts from one firm to another are very frequent, as illustrated in table 1.⁵

⁵ The fact that it is not unusual to change from one firm to another several times a year indicates that the mobility of craftsmen, as reported in chapter 5 is somewhat understated.

Table 1: Mobility of carpenters – observation from the case study on roof construction

	Seniority (working years)	Number of employers (firms) for the whole period	Maximum number of employers within a single year
Carpenter 1	10	10-15	(n.i.)
Carpenter 2	10	10-15	(n.i.)
Carpenter 3	10	7-8	(n.i.)
Carpenter 4	10	20-25	6
Carpenter 5	10	5	(n.i.)
Carpenter 6	38	(n.i.)	(n.i.)
Carpenter 7	28	25	3-4 employers has been common

The low degree of firm specialisation was very clearly illustrated in one particular part of the case study. Midway through the building project, the four carpenters mentioned above decided to leave the project due to dissatisfaction with their salary and because they would like to work in their six person clique without foreman. They announced this in the beginning (Tuesday) of the week in which they quit. New carpenters, previously employed in another firm, were hired by the clerk of works and started the following Monday. They met, as always, at 7.00 and after eating breakfast and talking socially (among other things about which sites and firms each of them had worked on), the foreman showed them the site, equipment was handed out (each carpenter got a tool box), one or two questions were asked and at 8:15 work was carried on, as if they had worked there for many weeks. Yet, the work proceeded a bit slower in the beginning (for instance, the crane driver assessed that the speed of installing windows was approximately 20% lower than for the previous crew), but as reported by one of the carpenters:

“How long time it takes before you operate at maximum speed depends solely on the activities. There is no extra time spent on starting in a new company – the time spent on shifting from one activity to another is the same in a company as between companies”.

Finally - as a sign of the limited division of labour and specialisation within a trade - the carpenters stress that it is important to be good at doing a bit of everything, “to be flexible”. Even though the activities involved in construction are similar from one project to another in some respects, they are never completely identical, and consequently the carpenters always have to adapt to new situations. As the right way to perform an activity depends on a wide range of changing conditions, it is not easily learned. As expressed by one of the carpenters:

“As an apprentice, it was extremely confusing that the exact way to do things varied from time to time and from one carpenter to another. A lot of times I thought “now I got it”, but it then turned out that for “this and this reason” I had to do it a bit differently. There are so many ways to solve what appears to be the same job - which one to use is very much a matter of feeling.”

As this quote illustrates, the right way to perform an activity depends on a lot of nuances that are very difficult to codify. Hence, it is difficult to establish formal rules that specify exactly what to do. This in turn implies that decisions on which working procedures and tools to use are made locally by the craftsmen. Further evidence of these elements of craft-production is given in the section on coordination modes that follows.

6.2.2 Coordination modes

As part of the case study, the coordination modes used during the process of constructing the house were identified. For each activity, the craftsmen were asked how they found out how to solve the various coordination objects. For instance, “How did you find out that it was you who should do this job” (“Who to conduct job” etc.). Answers could be given on a five-point Likert scale (1: Not at all, 2: only to a small extent, 3: to some extent, 4: to a large extent, and 5: completely) according to a typology of coordination adapted from Grandori (see chapter 3). Chapter 4, (section 4.6.1) gives further information on the methods and operationalisations - among other things of coordination modes - used in this connection.

The overall results on coordination modes in roof construction are reported in table 2.

Table 2: Coordination practices in the case of roof construction - overall results based on registration of twelve activities⁶

Coordination object	Who to conduct	When to conduct	Which materials to	How much to produce	How it should look like	Which tools to use	How to do it	If quality is OK	What to do if in doubt
Coordination mode									
Authority 1 - Instructions from foreman	4 (3)	4 (2)							
Authority 2 - Instructions from clerk of works / management of firm	4,3 (3)	3,8 (5)	3 (2)	5 (1)		3 (1)			3,6 (3)
Authority 3 - Instructions from project management		2,6 (3)						4 (2)	
Authority 4 - Instructions from architects and engineers (e.g. drawings and instructions)		3 (2)	4,2 (5)	4,7 (7)	4,4 (7)		2 (1)		
Pricing - Using the contracts signed when tendering took place.	4,5 (2)		4 (1)						
Teaming - Talking to other craftsmen, suppliers etc.	2,5 (2)	3,5 (2)		2 (1)	2,5 (2)	2 (1)	2,5 (2)	5 (2)	3 (1)
Formal rules - Using general and written line of directions (e.g. instructions for use)				2 (1)					
Social norms 1 - By assessing the task and use my experience.			2 (1)			2,5 (2)	4 (1)	3 (2)	3 (1)
Social norms 2 - Not something I think about, I do as I always do.			4 (2)		4,5 (2)	4,8 (6)	4,8 (6)		
Other		5 (1)	3 (3)					3 (2)	3 (1)

The first figure in each box represents the average of the reported values on the five-point Likert scale. The figure in brackets represents the number of observations (i.e. observations with the value of 2-5). For instance, the value 4 and (3) in the first box means that in three cases a

⁶ Eight activities performed by carpenters (construction of roof houses, making heads, erection of rafters, installing edge strip, covering rafters with wooden plates, wooden frame for eternit-covering, installing gratings, install plates of eternity); one activity by the crane driver (delivery and hoisting of building materials); one activity by the roofing felt contractor (making the roofing felt); one activity by the ventilation contractor (installing ventilating plant on roof); and one activity by the plumber (installing the gutter). Notice that no reports have been made for the producers of the carcass and for the surveyor.

craftsman reported, that he undertook this activity due to instructions from the foreman, and that on average, these instructions “to a large extent” determined this. An empty box signifies that no use of this coordination mode was reported.

The similar approach was used to study coordination forms in the test study of installment of windows (Table 3).

Table 3: Coordination practices in the test study on installment of windows – general practices according to the carpenters⁷

Coordination mode	Who to conduct	When to conduct	Which materials to produce	How much to look like	Which tools to use	How to do it	If quality is OK	What to do if in doubt
Authority 1 - Instructions from foreman	4	4	2			3		
Authority 2 - Instructions from clerk of works / management of firm					2			
Authority 3 - Instructions from project management							5	
Authority 4 - Instructions from architects and engineers (e.g. drawings and instructions)			3	5	5	3		
Pricing – Using the contracts signed when tendering took place.								
Teaming – Talking to other craftsmen, suppliers etc.	3	3				3		
Formal rules – Using general and written line of directions (e.g. instructions for use)								
Social norms 1 – By assessing the task and use my experience.			4		4			
Social norms 2 – Not something I think about, I do as I always do.						3		
Other								

Interestingly, as highlighted by the grey areas, there appears to be a dominant coordination pattern for activities related to the roof (and for installment of windows):

⁷ This table summarises the approx. 20 hours of interviews and observation done on the installment of windows. The data is collected according to the same principles as used for table 2. Unlike in the final case study on roofing, however, the coordination modes were not mapped for each activity. Instead, the carpenters were asked towards the end of the installment of windows, how they had experienced that coordination was executed for this job. Thus, the reported values may on some occasions reflect an average (estimated by the carpenters) of multiple activities.

Coordination object	Who to conduct	When to conduct	Which materials to produce	How much to produce	How it should look like	Which tools to use	How to do it	If quality is OK	What to do if in doubt
Coordination mode									
Authority 1 - Instructions from foreman									
Authority 2 - Instructions from clerk of works / management of firm									
Authority 3 - Instructions from project management									
Authority 4 - Instructions from architects and engineers (e.g. drawings and instructions)									
Pricing - Using the contracts signed when tendering took place.									
Teaming - Talking to other craftsmen, suppliers etc.									
Formal rules - Using general and written line of directions (e.g. instructions for use)									
Social norms 1 - By assessing the task and use my experience.									
Social norms 2 - Not something I think about, I do as I always do.									
Other									

When an activity is to be done and by *whom* is mainly decided by authorities within the firm, that is by the foreman or the clerk of works. During roof construction, usually the same two carpenters worked on the roof, however, in busy periods additional persons, one of them the foremen, stepped in. In this way, one might expect that instructions on *who* and *when* were given once and for all in the beginning of roof construction. However, the carpentry work on the roof was not done continuously. As seen in figure 2, activities by other trades have to be performed in between, and in order to utilise manpower, the two carpenters were allocated to other tasks on a weekly, if not daily basis, for instance to making sheds, installing windows, working on the roof of building number two etc.

In fact, by being able to shuffle manpower around, it is possible for the management of the firm to avoid idle periods, even though there in some cases are substantial delays in some of the previous activities performed by other trades (for instance, the bricklayers were more than 1½ months delayed with the facing wall, which obviously delayed the completion of the roof-band accordingly). The three other carpenters were organised accordingly, two of them always worked as a team and the fifth one, as

well as the foreman, worked on their own or in different constellations, but on different activities. Undoubtedly, this constant reallocation of manpower solves a problem of optimising resources in situations of high (time)dependence, but it also requires constant coordination efforts by personal authority.

External authority, as represented by the design team, coordinates the next three objects: *which materials to use, how much to produce, and the finish* of it. Instructions are nearly always provided in drawings and written description as the architects and engineers very rarely show up at the roof themselves (in fact, some of the carpenters did not know who they were or how they looked like).

This raises the question of how it is ensured, that the instructions from the design team are followed. In particular, because the quality of all the intermediate and often in-built output are hard to assess by the client or client representative when the finished building is handed over (*asymmetric information* is substantial). To some degree, project management has the responsibility for following the building project as it evolves. Yet, as indicated in the next to last column in table 2, project management is not the only way *quality is ensured*, and indeed it would be very difficult for project management to examine all of the building processes in detail (they would have to be more or less permanently on the roof). Nevertheless, the contractors may not try to “cut corners” after all, as deviations from the specifications, and thus from the contract, inflict a risk of reduced payment. Perhaps the project management does not see such deviations in the first place, but learns about them from other contractors, who have been troubled by the “easy” solutions of a contractor upstream in the value chain. In this way, the scattered production of the single contractor on the one hand creates a need for external coordination, but on the other hand might solve some of the problems of monitoring associated with these.

The materials used by the carpenters are provided by the clerk of work or the foreman according to the same design descriptions, but even with a limited bulk of material, the craftsmen have to consider the drawing in order to see exactly what material to use and what to use it for. This has to do with the general applicability of the materials: a pile of wooden boards and strips can be used for almost everything. Thus, the inflow of

materials only to a very limited degree coordinates exactly which materials to use, how much to use, and the finish of it.

For the same reason - moving onwards to the next coordination objectives - *which tools to use* and exactly *how to carry out the job* is only to a very limited degree specified by the input provided by the building materials and outcome of previous activities. Here, the craftsmen rely on their experience. Without much reflection, they take the appropriate (and multi-purpose) tool from the toolbox, and carry out the job. However, in the beginning of an activity, the carpenters might occasionally discuss how to do it with each other. These decentralised decisions - and decisions taken individually by the carpenters without communication - resemble what in chapter 2 was termed craft production.

As mentioned, control of *quality* is partly carried out by authority exercised by project management, partly done by firms in subsequent activities. Finally, *resolution of doubts* is done by different coordination modes with instructions from the clerk of works or the management of the firm as the dominant one.

Coordination modes not in use

It is worth noting which modes of coordination do not seem to be in play at the level of the craftsmen.

First of all, instructions by project management play only a limited role at the level of craftsmen. However, at higher organisational levels, project management is more visible. Among other things, project management provides an overall timetable, specifying when (in which period) the activities have to be carried out. The timetable is open to some debate, as witnessed in the weekly site meetings in the social housing project in Farum (see appendix A), where a substantial part of the meeting was used to report the progress of the different trades. If there are delays the project management can interfere, but very often it is representatives from other trades that come up with remarks. In this way, the weekly site meeting can be seen as a forum for coordinating the timing of activities in a combination of authority (project management) and teaming (the trades talking directly to each other).

The use of the contracts signed when tendering took place (or what with reference to Grandori could be perceived of as coordination by pricing)

is only reported on two occasions. Both of the reports are made by the foreman, who had the double position of being a carpenter and a superior. It is likely that the reporting relates to the latter position of the foreman, suggesting that on the level of the craftsmen, the documents provided by tendering or similar negotiations are not used directly for coordination. However, this naturally does not exclude that prices can be an important way to coordinate the allocation of resources at higher hierarchical levels or in earlier phases of construction.⁸

Finally, formal general rules are not used at all by the craftsmen. This is perhaps somewhat surprising, considering the many different forms these rules can take. First of all, there are descriptions of some of the slightly more manufactured building materials, such as windows or hatches (on which observations were made as part of the test study). For these products, a description of how to install the products is attached to the product, but the carpenters hardly ever use them (in fact they seldom unpack them). The substantial amount of very specific regulations written by public research institutions or trade associations is another example of formal rules, which are not used directly for coordinating the behaviour of the craftsmen (of course, this does not necessarily prevent them for being used at higher organisational levels). And as final example, the very detailed working procedures, developed as part of the piece rate system, should be mentioned. None of the craftsmen referred to these with respect to coordination of the various objectives.

The fact that the craftsmen do not mention the piece rate system as a means to coordination, does not imply that this system serves no purpose. First of all, as payment is done according to the piece, and not by the hour, it is a powerful way of reducing problems of shirking in situations, where the actions of the employees is difficult to monitor. Secondly, the cost of writing contracts can be reduced, as these are often written with reference to the common and very detailed piece rate system (see box 4). In this way, the piece rate system can, as the existence of trades, be seen as a way to establish a standard interface for interfirm relations and thus enable interaction in one-offs relations (of course this

⁸ In fact, the common - and for publicly supported building projects *mandatory* (unless exemption has been granted) - use of price-based tendering in Denmark suggest that pricing indeed is important prior to the phase of execution.

does not suggest that the common piece rate system is a prerequisite for forming such contracts). However, the formal obligations and payments specified in the contract are usually far from what actually takes place. Hence, the piece rate system enables agreement on contracts prior to the execution phase, but plays a much more limited role during execution. A possible explanation of the coordinating role of these initial contracts, discussed later in this and the next chapter), is that the contracts coordinate work (originally provided by the client) and labour (provided by the contractors) at an aggregate level. Or put differently, these contracts ensure that each contractor at any given point has a sufficient “heap” of assignments to play around with. At the firm level this “playing around” is done by the clerk of work or master allocating manpower between building projects. At the project level, the foreman allocates manpower to specific parts of the project. In this way, the coordination of work and labour is solved in a sequential process by use of different coordination mechanisms.

Box 4: Payment schemes in construction – the importance of piecework contracts

Usually craftsmen on a building site are paid by the piece. The piece rate system is made and agreed upon by the non-governmental organisations representing the different groups of employers and employees found in construction. Consequently, it applies to the entire building sector. For each trade a dense piece rate manual is provided that in great detail specifies how much the craftsmen earn by carrying out a particular kind of work using specific materials and tools. These manuals are deeply rooted in the daily life of construction. Subcontracting firms are usually paid according to the system and hence are descriptions of assignments - used for instance at tendering - often done simply by referring to identity numbers in the manuals of the respective trades. The craftsmen are usually also paid according to the system on an individual basis. However, as seen in the case study, it is not uncommon that people working in the same trade group decide to group together their payment.

To a certain degree, the piece rate system takes into account how many times a certain task is repeated (the more repetition, the less payment per unit). Yet, the payment does not always reflect the time spent – especially not for very small batches. In an example from the case study, two rather hardworking carpenters used in total approximately seven hours on installing a hatch in a loft. The piece rate of such a work is a mere 137,59 DKr (approximately 15 ECU equalling a time wage just beyond 2 ECU). In order to compensate for this, fixed prices are occasionally used. Some companies also ensure a minimum salary beyond the level of the general minimum salary.

(Continues)

Box 4: Payment schemes in construction – the importance of piecework contracts. Continued.

However, according to the carpenters in the roof case, it is by claiming "extra-payments" it is possible to maintain a reasonable salary. Extra payments can be claimed when there are deviations from the description of the assignment (usually made by a general contractor or by the design consultants). As observed in the case study, lunch breaks are usually used for filling out extra payment claimant forms.

The carpenters are, in many ways, not very pleased with the piece rate system. First of all, they think they waste time on discovering and reporting deficiencies in plans. Secondly, as one of the carpenters expresses it, "the whole idea of the piece rate system is that you do not think yourself". Since everything, at least in principle, is described very carefully in the outset, it does not make sense for the carpenters to put forward ideas that might improve the working process or the final product. It is very frustrating, the carpenters find, not to be able to use their "hands-on" experience. For the same reason, the carpenters prefer a differentiated performance pay ("slump akkord" in Danish meaning something like "performance pay based on a rough estimate") as often used in refurbishment projects. In this payment system, the craftsman personally accesses a particular piece of work and agrees on a price in cooperation with, say, a foreman or clerk of works.

But why then does the piece rate system exist according to the carpenters of the case study?

Firstly, since prices are known and agreed upon in advance, it is possible to estimate the cost of the building prior to building it. However, claims for extra payments can easily ruin this advantage. A second, and according to the carpenters, more valid reason is the difficulties of monitoring how hard working they are. If they were paid a fixed salary, it would be very hard for managers to avoid shirking. The same reason is given to why construction companies are usually small. Small units make it easier to detect faults or shirking and hence are preferable when the doing of a person are hard to observe directly. Even larger firms are usually divided into profit centres. For instance the painting firm working on the roof case building project is split up into three separate economic units with approximately 13 employees in each. Finally, a piece rate system can also be a way to impose improvements in productivity. By lowering the piece rate over time, contractors and in turn employees are enforced to come up with improvements (however there is also the danger that contractors and employees hide or do not fully utilise an improvement in working processes in order not to bring about an, in their view, unfavourable change in the piece rate system).

A few carpenter-firms do not pay their employees by the piece, but uses a fixed hourly rate. However, fixed rates are only offered to employees with some seniority. A possible interpretation is, that by doing so, the company screens the employees and only keep the ones (assumedly) requiring little monitoring.

The multiplicity of coordination modes

The limited use of instructions from project management, the limited use of prices and the limited use of general rules (including the piece rate system) at the level of the craftsmen all illustrate one point: how coordination modes can change over time and for different organisational levels. For instance, at the level of the craftsmen, the timing of activities (“when to do”) is decided by authority exerted by the foreman / clerk of works. However, at the level of project management and foremen / clerk of works, it is partly decided upon by teaming. Similarly, the content of drawings and technical descriptions is given to craftsmen from the design team as the project evolves and in this way represents coordination by authority. However, in the planning phase (and in the ongoing adaptations during construction) these drawings (or at least establishing the detailed principles for their completion) are mostly an outcome of mutual agreement between the architect, engineer and main contractor in the design team. Hence, at this level and in this phase, coordination is done mainly by teaming (or negotiation). Or, to take the example of the piece rate system, it is an important facilitator of coordination by price in the early phases of construction, but plays a more limited role with respect to obligations and payments in later stages.

Theoretically, it is not very surprising, that coordination modes can change over time and for organisational levels, as the information involved in coordination also could be expected to change. However, methodologically, it is a useful reminder of the importance of pointing out in which phase and for which organisational level, coordination practices are analysed.

6.2.3 The organisation of coordination

Figure 2 illustrates another significant feature of construction: the activities carried out by a firm are very scattered; one firm performs one activity, another firm the next, and eventually the first firm enters the value chain again, etc. Since larger strings of activities are not internalised within a firm, a substantial part of coordination is carried out between and not inside firms.

The way interfirm coordination takes place varies according to the objective (see table 2) and organisational level. At the level of the craftsmen, the foreman and the clerk of works decides when and by whom an activity should be performed; i.e. *authority within the firm*. Again, their decisions are based partly on a common agreement on the weekly site meeting, partly on instructions from project management. Hence, for these objectives interfirm coordination is done beyond the level of the craftsmen in a combination of teaming and authority, mostly residing outside the construction firm (except in those cases where the construction firm is identical to the contractor in charge of project management). With respect to which materials to use, how much to produce and how it should look, interfirm coordination is done by the design team, who instructs the different trades directly (based on an overall plan for the project). Finally, tools and working procedures are coordinated between firms by the norm-following behaviour of the employees.

Third party coordination

Thus, an important characteristic of construction is the existence of overarching coordinating firms specialised in coordination. Or put differently, the existence of firms, that do not carry out activities directly on the building project themselves, but solely instruct – often in a very direct and detailed way – how other firms should conduct their activities. Two different kinds of firms specialised in coordination are identified in the case study: *the project management* and *the design team*. As I will return to in the discussion in chapter 7, the work done by these specialised coordinators serves as an entry point to a more general understanding of the advantages and disadvantages of third party coordination. Here, it is sufficient to notice, that a substantial part of

coordination in the process of construction is done by what was termed *trilateral coordination* in the theoretical part (as in the case of the design team), or by *unilateral coordination with separate production* (as it is usually the case with project management).

In this way, the construction firm does not partake in coordination along the value chain, i.e. the coordination of subsequent activities. Some aspects of this coordination is placed at higher organisational levels (i.e. with the design team and project management), other aspects are transferred “downwards” to the experience and skills of the craftsmen.

Construction firms only carry out coordination between different building projects, or between “non-neighbouring” activities on the same building project (for instance, allocating people from roof activities to construction of sheds for bicycles). The purpose of this is to optimise the use of production facilities in general and of manpower in particular. As reported in table 2, the foreman and the clerk of works decide on when and by whom an activity should be performed. This decision is not merely a reflection of the overall timetable or the decisions made by the project management. First of all, the decision on how much manpower to use is in the hands of the firms. And as such, it is the clerk of works, or in smaller firms the master, who shuffle around manpower from one building site to another, in order to balance stable employment with the fulfilment of deadlines. Secondly, the timetable establishes overall deadlines and consequently leaves some space regarding the exact moment for execution of a single activity. The constant deviations and rearrangement of the timetable - agreed on at the site meeting - furthers the need for constant decisions on when to do what.

Ongoing sequencing

Thus, a lot of resources at the project and firm level are devoted to finding a sequence of activities that, among other issues, enhances accessibility and reduces the amount of rework due to damages caused by, say, other trades or the weather. The sequence of activities varies very much according to the final product.

To illustrate: one part of the building project included a two-story playing room for a kindergarten. Due to the height of this room, an indoor scaffold had to be used for installing the lowered ceilings. Pipes

for radiators could not be installed and the floor could not be put down until the scaffold was removed. Hence, the carpenters were forced to complete the lowered ceiling rather early in the working processes. This is not the usual procedure as the gypsum plates easily pick up dirt from subsequent activities. In short, a variation in the building (the two-story room) brings about another sequence of activities than the one usually used for single-story rooms. To take another example, in this building project, rather large windows were used for the staircases. Consequently, they had to be hoisted by a crane instead of carried by the carpenters, as it is the practise for smaller windows. This in turn implies that the outdoor scaffold, which is necessary to build some parts of the roof and to build the brick facade, cannot be erected before the installment of windows is completed. Here, the use of certain building parts (a large window) triggers a late start on other parts of the building.

One way to cope with the various interactions between activities is to provide very detailed schedules for their completion. However, as one activity cannot be completed before the successful completion of a wide set of other activities, delays frequently occur (a point I shall return to). This in turn creates a need for constant replanning of the sequence of activities, and thereby explains why the issue of staffing largely takes place ad hoc on the building site by the project management, and why the decisions in the various construction firms are not laid down ex ante, for instance in the specifications from the design team (specifications that in turn could be part of the contractual obligations of the contractors).

6.2.4 Informational properties of roof construction

So far, the information involved in coordinating roof construction has not been addressed. Since information properties have been pointed out as a potential explanation for the use of certain coordination modes in the process of construction, this section focus on these properties. To recall the discussion in chapter 3, three information-related variables were pointed out: variability (i.e. non-repetitiveness), complexity and the number of people involved in coordinating an activity with other activities. In the following, roof construction will be analysed according to these variables.

Originally, questions relating directly to the variability and complexity of activities were developed. However, for methodological reasons

mentioned in chapter 4, these questions turned out to be difficult to apply. Consequently, these variables have to be assessed by other means. A central means is the mapping of *interdependencies* found in roof construction and therefore, this section starts by looking at these.

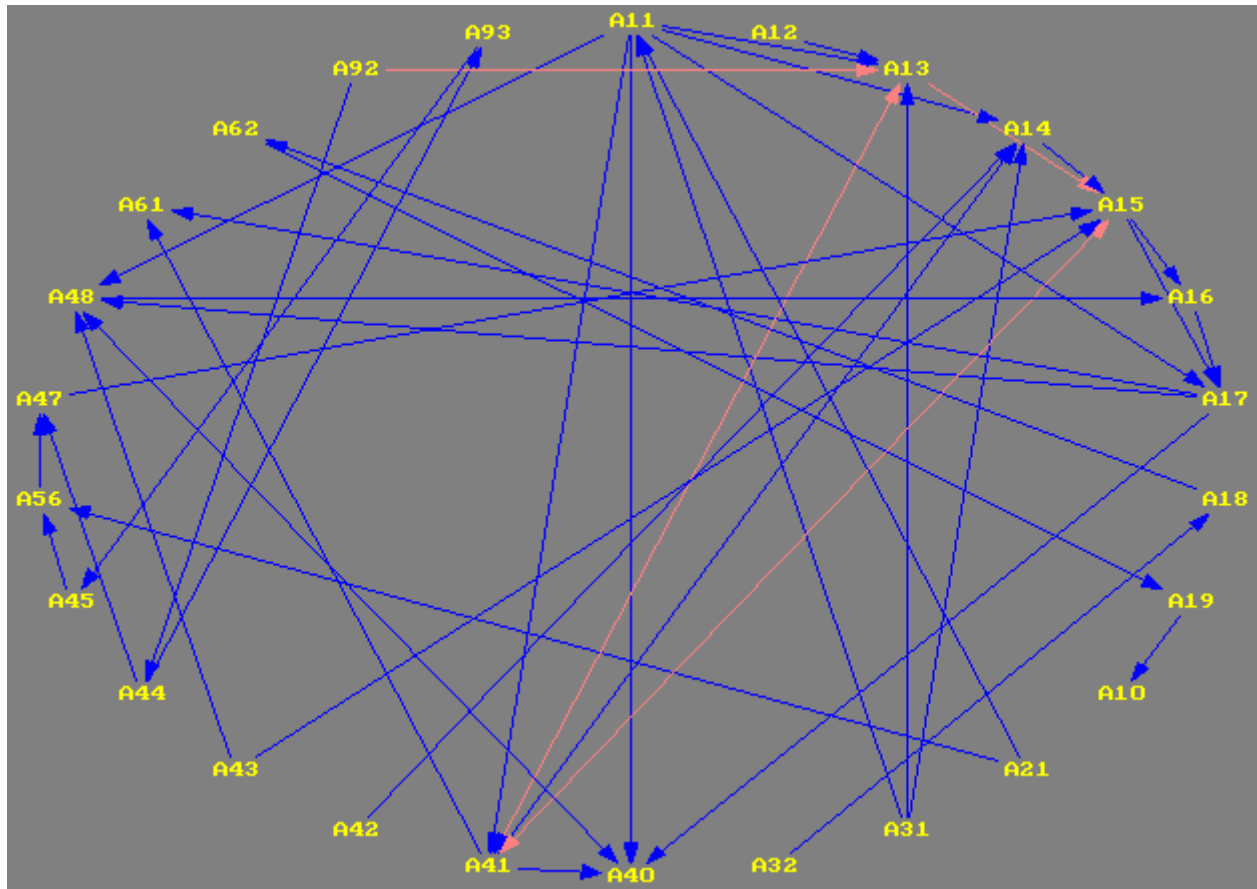
As part of the standard questionnaire used for all 18 activities involved in roof construction, the craftsmen was asked “*What other jobs in this project affect the execution of this job?*”. The activities mentioned were noted and the interdependence specified according to six different types of interdependence, which were located as part of the test study on the installment of windows (see chapter 4 for a more full description of the methods used):

- *Time-dependence*: the degree to which other activities have to be completed before this activity can be commenced;⁹
- *Material-dependence*: the degree to which other activities affect which materials to use for this activity,
- *Tool-dependence*: the degree to which other activities affect which tools and equipment to use for performing this activity),
- *Method-dependence*: the degree to which other activities affect which methods / working procedures to use for this activity;
- *Access-dependence*: the degree to which other activities physically obstruct the physical accessibility needed to carrying out this activity); and
- *Damage-dependence*: the degree to which other activities affect the quality of the result of this activity, for instance by damaging or making the outcome dirty.

Based on these answers, a network diagram of the interdependencies found in roof construction can be drawn (figure 3).

⁹ Originally I expected this kind of time-interdependence to be supplemented with a variable called *urgency-dependence*; that is the dependence related to performing one activity quickly after another, for instance, due to building materials that harden or in order to protect vulnerable building parts from rain etc. Undoubtedly, interdependencies of this kind exist in construction, but they were not found to be important in the test study on the installment of windows, nor in the case study of roof construction.

Figure 3: Interdependencies of activities in roof production



Explanation: The numbers represent the major activities involved in roof production.¹⁰ Based on the test study of installment of windows, the concept of “interdependence” has been decomposed into six different sub-categories and then measured on a five point Likert-scale. Green arrows represent interdependencies summing up to five or less. Red colours represent situations where the sum of the six different interdependencies adds up to six or more (and hence represents at least two kinds of interdependencies).

¹⁰ 11=: delivery and hoisting of building materials, 12= installment of safety railing, 13= construction of roof houses, 14= making heads, 15= erection of rafters, 16= installing edge strip, 17= covering rafters with wooden plates, 18 = wooden frame for eternit-covering, 19 = installing gratings, 10 = covering with “eternit” plates, 21= making site accessible, 31= construction of concrete carcass, 32 = bricklaying of facing wall, 40= making the roofing felt, 41= installing ventilating plant on roof, 42= surveyor mark out roof, 43= putting up scaffold, 44= design of rafters, 45=producing rafters, 56 = delivery of rafters, 47=hoisting of rafters, 48= installing the gutter, 61= doing the concrete around ventilation tubes and soil pipes at top of carcass, 62 = zinc-covering of top edge of brick wall. 92=overall design of roof by architect, and 93= approval of design of rafters (by architect).

The interdependence of activities exceeds just being dependent on the previous activity. In the figure, such a situation would show as one arrow going to, and another leaving, each node. But as seen in figure 3, there are usually more connections resulting in network density for the investigated interdependencies of 3.9 (each node has in average 3.9 connections).^{11 12}

In this way, even a very simple activity (in technical terms), like making the heads¹³ (A14), can be dependent on numerous activities: hoisting of building materials (A11), the surveyor marking out where to place the heads (A42), installation of the ventilation plant (A41) (forcing the carpenters to cut the heads in order make room for ventilation tubes), and of course also the completion of the concrete carcass on which the heads are installed (A31). On some occasions, the interdependencies build up for the activities towards the end of the value chain – as seen in the case of installing the gutter (A48) – but this is not necessarily the case, meaning that high interdependence can be found in all parts of the value chain. Hence, there does not seem to be any clear temporal dimension of interdependence (e.g. the interdependencies are not concentrated towards the end of the project). Probably, this increases the cost of discovering the true values of the interdependencies of this particular kind of roof.

Time interdependence to a medium or strong degree was reported for all activities and thus, time interdependence accounts for the vast majority of interdependencies. The strength of this type of interdependence probably relates to the specificity of inputs that makes buffering by storing or by substitution very costly. For instance, it is almost

¹¹ The density for all 26 nodes in the network is 2.9. However, only 18 of the nodes have been subject to investigation in the case study – the remaining 8 are included because they are mentioned in the inquiries of the 18 nodes. Since the interdependencies of the remaining 8 nodes have not been investigated for all potential interdependencies, these are probably understated.

¹² Furthermore, some interdependencies are probably understated due to the bias only to report interdependencies in which problems occur. For instance, it is likely that the overall design of the roof by the architect (A92) had to be in place for at least those seven activities, where use of documents from the architect is reported (see Table 2). Unlike relations where both activities are performed at the roof, dependence on an off-roof activity like design is more difficult to check by observation.

¹³ The heads are the horizontal wooden beams fixed lengthwise to the carcass. Fittings are nailed to these heads in which the rafters are later placed and attached.

inconceivable that the time interdependence inflicted on the installment of faces by the carcass could be reduced by building a stock of finished carcasses on the site (where to place these?) or by taking in another supplier of the carcass.¹⁴ Even though this example is extreme with respect to the size and costs of the input (the carcass), it is common to most intermediate construction products as they are built in and customised to a particular project.

Delays are frequent in this system. Not only is each activity directly dependent on the successful completion of multiple other activities (activities do not flow in parallel). Indirectly, delays rapidly propagate from one part of the system to another due to rather high network density.

This in turn implies that the number of people and firms that have to be taken into account in order to know when an activity can be performed, is rather high. A contractor cannot commence his activity before a number of activities upstream the value chain are completed. And in order to gain prior knowledge about this, the completion of activities one step further up the value chain also have to be considered, and so forth. In particular because the contribution of each firm is usually very restricted, the “warning time” from only considering neighbouring activities (and not activities that are two steps or more up in the value chain) is very limited.

The co-located production – i.e. that all trades carry out their production at the same building site – complicates the exercise of making the various activities fit together. Firstly, there is the question of accessibility. As various firms are working on the same part of the building, it may be difficult to gain access to this part. Presumably, the roof is not the worst part of the building in this respect, due to its large size (toilets and kitchens appear to be more difficult, as many persons have to work in a very narrow space (see box 2)). At the same time, materials are delivered in large bulks in order to reduce lift expenses, which obviously raises the question of where they should be placed (as for instance witnessed in a disagreement between the people doing the ventilation plant and the carpenters). Secondly, co-located production raises the risk of damages

¹⁴ For reasons of production time alone. It takes at least 6 weeks from the time the precasted concrete elements are ordered, until they are delivered.

stemming from subsequent activities, so this is also an aspect to consider with respect to coordination.

On top of this, there is also the interdependence of materials, tools and working procedures to consider.

6.2.5 Coping with the information involved in roof production

Thus, contractors, project management or the design team face an apparently enormous job of coordinating the novel and in turn many-sided and multiple interactions between construction activities carried out by multiple contractors. One way to cope with this situation would be by planning, that is exactly specifying when each activity should be performed, specifying exactly which working procedures to follow, exactly where to place building materials *ex ante* production. At first sight, it is tempting to believe that this is actually what happens (or should happen) in construction – after all, rather detailed time-plans and drawings are made and are on some projects, as for instance the case study followed, plans for logistics used to specify when and where building materials should be placed etc.

“Project errors”

However, such plans clearly do not take everything into account. As it was observed on several occasions, some interactions were recurrently overlooked, mistakes were inevitably made or delays propagated through the system, resulting in late delivery. This is reflected in what the contractors called “errors in project” (“projektfejl” in Danish). These so-called “errors in project” were observed on many occasions in roof construction (Ad A-G) and incidentally also on other parts of the building project (Ad H-J):

- (A) *Reconstruction the roof houses I:* After the first of three roof houses were constructed, a revised version of how to make the house was forwarded by the engineer. The modification caused the carpenters to make a new hole for the ventilation tube, including replacement of insulation (triggering 1½ hours extra work). It turned out that the hole in the top of the carcass was made according to the drawings made by the architect, but the ventilation plant was outlined according to the hole shown in the drawings made by the engineer. In other words,

the drawings of the architect and the engineer did not correspond. This was not discovered until the clerk of works on site had a meeting (taking place on the roof) with a representative from the ventilation firm to clarify the last details.

The clerk of works doubted whether the new solution, worked out by the engineer and a superior from the ventilation firm, would work. But since the superior levels informed him to do so, he instructed the carpenters to perform the work accordingly.

- (B) *Reconstructing the roof houses II*: As anticipated by the clerk of work, the new solution did not work. There was not enough room for the ventilation tubes. Consequently, the carpenters had to remove the insulation material in the roof in order to make space (it was not replaced by other means of insulation).
- (C) The faces blocked some of the holes made for the (vertical) ventilation tubes, and consequently, parts of the faces had to be removed. According to the carpenters, it would not had been a problem if the faces have been placed a bit differently - this error simply arose because the design consultants sometimes forget to put the drawings “on top of each other”.
- (D) The (horizontal) tubes used for ventilation did not fit into the prefabricated rafters, and consequently, the rafters had to be sawed through and secured with laskes¹⁵. Originally, the idea was to place the tubes at the high end of the rafters, where there is plenty of room for the ventilation tubes. However, the architect feared that it would be impossible to get access to the loft and consequently moved the position of the tubes towards the narrow part of the loft. In this position, there was not enough space between the crossbeams of the rafters, and as a result, some of the crossbeams were removed and replaced by laskes on site.

¹⁵ Laskes are wooden beams nailed to the rafters in order to compensate for the part of the rafters that was removed due to the installment of the ventilation tubes.

- (E) The ventilation people had to remove the ventilation tubes installed since it turned out that the rafters were not in the right position.
- (F) The persons doing the concrete around the ventilation tubes and waste pipes were not called in at the right time. Consequently, they had to do the concrete *after* the wooden plates had been nailed to the rafters, prolonging the man-hours spent from approximately 8 to 32 hours due to difficult access (the distance between the plates and the concrete carcass was down to 30 cm).
- (G) The two persons doing the roofing felt came to the building site according to the timetable. Unfortunately, their clerk of works was not informed that the carpenters were delayed and that roofing had to be delayed accordingly.
- (H) Windows at the corners of the kindergarten did not fit due to a miscalculation made by the producer of windows. For this reason, a temporary shelter (of plastic) had to be installed in order to allow the building to dry out by heating (getting the right humidity is important for painting and floor-making).
- (I) Some of the windows were produced according to the plan, but did not fit in the openings of the building. Apparently, the architect did not take into account that the top windows had to be narrowed.
- (J) The angled fittings developed by the design team and produced by an external blacksmith for the installment of the big windows in the staircases did not fit. The holes did not allow for adjustment in the position of the screws and consequently, the small variations in the carcass could not be absorbed. In order to secure that the windows were in line vertically, some parts of the wooden frames of the windows had to be removed. This turned out to be a rather costly procedure as it could only be performed when the window was hoisted to its right position, causing all four persons involved in the installment of windows to be delayed.
- (K) The design consultants did not take the water pipes into account when calculating the space beyond the lowered

ceiling. Consequently, there was not enough room for the ceiling lights and in some parts of the building the in principle finished ceiling had to be lowered. This operation includes prolonging of straps (in which the ceiling hangs) and replacement of strips (fixed to the wall along the edge of the ceiling).

- (L) At the kindergarten: the drawings used for the position of the roof did not correspond to the drawings used for the position of the brick-wall. Consequently, the plumber had to patch up the difference during application of the zinc covering.

According to the two most experienced carpenters, the exact types of project errors are specific to this building project. However, errors occur on all projects; in fact errors of this magnitude are not at all particular to this project, but are typical to all the projects, that the carpenters have been involved in.

In the perspective applied in this thesis, the examples given here do not have to be “errors”, but can represent a sensible way of balancing the costs of making plans (getting information) with the benefits of having (an efficient) plan (i.e. having information). Particularly due to the limited repetition (outlined in chapter 5 and appendix A.), the benefits of reducing uncertainty *ex ante*, and the potential for learning from past experience, is limited.

Authority exerted by the project management working on the site is one way of making the *ad hoc* adjustments enforced by these project errors. Teaming is another option, i.e. agreements reached directly between the involved craftsmen. But as seen in table 2, these are only used to a very limited extent.

Ad hoc planning and buffering of time and activities

In general, coordination of activities on the building site is not solved by specification, but by *non-specification*. Or put differently, some degree of flexibility is built into the process of production, whereby the need for coordination is lowered (but at the same time, production costs are probably higher due to less repetition). This is done in various ways.

As hinted previously – and not surprising, considering the high level of time-interdependencies – more detailed timetables are often not kept in

construction.¹⁶ Yet, the foreman of the work did not consider this to be particularly frustrating as he just allocated the carpenters to other activities on the site in the meanwhile, thus minimising the actual economic consequences of the deviations. This buffering was possible because the carpentry firm worked on many different parts of the building simultaneously: installment of windows, sheds for bicycles and garbage, putting down floors, installing lowered ceilings, erecting partition walls etc. Even though there was an overall timetable that had to be kept, this timetable was broad enough to allow some degree of shuffling around the activities. Furthermore, extensions could usually be obtained at the weekly site meeting, as long as they did not compromise the overall deadline of the house (the date of handing over). Partly overlapping phases further encouraged the possibility of shuffling around activities: first the construction of the kindergarten was commenced, then when this was roughly halfway done, the building of the first block of apartments was started and some months later the second block of apartments was initiated. Correspondingly, the handing over took place at three different dates.¹⁷

Adjustment to delays is further facilitated by exchange of labour *between* building sites. As noticed, the number of carpenters attached to the building project of the case study varied from 4 to 8. These carpenters came from / went to other building projects in which the carpentry firm was involved. Even though one should be careful to compare refurbishment with construction of new houses (see chapter 4), the study of a refurbishment referred to in box 2 seems to support the claim that

¹⁶ Which, as a researcher, could be rather troublesome, since I wanted to be present when activities on the roof were undertaken. Many times I showed up on the roof according to the timetable of the previous week, only to find out that for some reason or another, these activities were postponed. I later developed the habit of calling the foreman of the carpenters on the mobile phone the day before or the same morning that an activity was scheduled, in order to find out whether it would proceed as planned.

¹⁷ This way of staggering building projects is quite common in construction. As seen here, one advantage of doing this is that it enhances the possibility of shifting around from one activity to another and thereby reduces the impact of delays in previous activities. Furthermore, it is also a way to minimise on capital costs, as well as to reduce the adverse effects of the weather by advancing completion. A disadvantage of this staggered production is that the repetition of specific activities is lowered.

non-presence on a project, for instance due to exchange with other sites, can be quite intense (table 4).

Table 4: Actual presence of each craftsman: Percentage of fulltime presence on the site - Refurbishment case in Odense¹⁸

Carcass		Carpentry		Painting		Plumbing		Electrician		All
Craftsman 01	17%	Craftsman 01	43%	Craftsman 01 ¹⁹	128%	Craftsman 01	40%	Craftsman 01	22%	
Craftsman 02	26%	Craftsman 02	60%	Craftsman 02	22%	Craftsman 02	10%	Craftsman 04	2%	
Craftsman 03	16%	Craftsman 03	69%	Craftsman 03	24%	Craftsman 04	71%	Craftsman 05	9%	
Craftsman 05	24%	Craftsman 04	57%	Craftsman 05	12%			Craftsman 06	7%	
Craftsman 06	27%	Craftsman 05	27%							
Craftsman 07	34%	Craftsman 06	22%							
		Craftsman 07	6%							
Average	24%		41%		46%		40%		10%	28%

Calculated from Bertelsen 1996.

With few exceptions, each craftsman in the refurbishment case spent less than half the time on the site and in average, the craftsmen spent almost three quarters of the time elsewhere. Even though the refurbishment case is a small building project, it gives us reason to suspect that workers actually *do* work on many different projects at the same time. To the degree that this study is representative, the craftsmen will in average work on almost four different sites at the same time. For trades like electricians, the number is up to ten projects at the same time.

Thus, a not too tight a timetable and many activities to be performed at any given time, act as an important buffers for delays. This suggests that a reduced building time may decrease capital cost (as there are no incomes from the house until it is finished and used), but most likely also increase the cost of coordination (either due to more resources spent on coordinating or in a poorer coordinated state). Potentially, this claim is supported by, or is able to explain, the observations made by two of the

¹⁸ These figures have been calculated by assessing how many hours each person spent on the site compared with the number of working hours he would have spent (with a 37-hour week), if he worked fulltime on the site in the period, that his trade was active.

¹⁹ 128% can either represent an error of measurement or overtime.

younger carpenters in a discussion of the pros and cons of the piece rate system. Their experience was that as long as there is no hurry, usually the different trades pay attention to each other. However, when time is tight, in order to keep their own deadlines, the subcontractors are not willing to postpone their respective assignments. Consequently, these assignments are carried out even in situations where the respective subcontractors know the difficulties that this brings to the other subcontractors. The two more experienced carpenters gave more potential evidence on how a "loose" timetable can be important with respect to coordination. They stressed that shorter and shorter building periods are the main reason, why project errors in their view have become more common throughout their 30-year career.

The wide applicability of skills, tools and building materials

The flexibility in construction also relates to the skills and wide applicability of the simple hand tools used by the craftsmen. In fact, as referred in chapter 4, even in situations where project errors forced them to come up with a solution targeted at this particular problem, the craftsmen did not consider this to be different from what they usually do, as they always do things differently. In case smaller adjustments have to be made – for instance, sawing through a face or lowering the lowered ceiling a bit extra – the craftsmen perform these without any fuss. However, if changes are more comprehensive or require substantial rework – as in the case of the roof houses – the foreman or the clerk of work may be called for. However, this contact is not necessarily made in order to find out how to perform the activity, but is made in order to ensure the right to claim extra payment.

The adaptability of the craftsmen to "whatever may come" is facilitated by the use of building materials with low degrees of prefabrication, such as uncut wooden beams or plates. A lot of processing on site is involved in making these semi-processed products a part of the building. These materials can be cut in exactly the necessary size, as well as combined in various ways and thereby adapted to the particular circumstances of each activity. Hence, even though production costs of processing building materials on the building site is probably high due to small-scale production and less favourable working conditions, the limited use of prefabricated and highly specific products reduce on coordination

costs. This point was clearly illustrated in the test study on the installment of windows, where a prefabricated angle fitting caused serious problems to the carpenters (see Ad J in the project errors listed above).

Some potential drawbacks from ad hoc adjustments and adaptability

On the one hand, the flexibility of the construction process clearly reduces the costs directly involved in coordination, as less information has to be obtained, processed and distributed prior or during construction. However, the study also highlights some disadvantages of this flexible system. First of all, as craftsmen have to be prepared to do a bit of everything, resources have to be spent on their education. Secondly, the benefits from the division of labour are limited, because each craftsman works on a lot of different parts of the building project. Furthermore, as each activity may be affected by a wide range of different activities, the chance that two apparently identical activities (like for instance erecting rafters) are similar from one project to another, is very limited. This is why a carpenter with more than 30 years of experience considers building projects to be unique and, as a consequence, that he can only extract the most basic skills from the 20-30 roofs of a size identical to the one in the case study he has completed previously (see section 6.2.1). Thus, lowering of coordination costs happens at the expense of higher production costs. Thirdly, as seen in the list of project errors, rework or work that becomes troublesome because of difficulties in access is common in construction. Hence, savings made on the costs directly involved in coordination are partly paid for by the indirect costs induced by a less coordinated state.

Fourthly, to the extent that communication between different parties of the value chain is needed, it draws heavily on direct personal communication in all stages of production. The wide applicability of tools and building materials ensures flexibility, but at the same time they do not contain much information about how and when activities should be performed. Consequently, the potential for economising on information costs by providing specific tools or materials that can only be used in a certain way is very limited. Finally, the need for flexible building materials also reduces the potential for replacing small-scale

production on site with larger-scale production under more favourable site conditions on site.

6.2.6 Coordination of highly interdependent activities – the case of roof houses

The previous section described the means by which different types of interdependencies in general are tackled. However, there are cases where activities interact in a more complicated way. In the roof case, this is the situation for the interaction between the carpenters doing the roof houses and erecting the rafters, and the people installing the ventilation plant and ventilation tubes. This part of the roof construction turned out to be difficult to coordinate due to a combination of incidents, that can be traced back to the characteristics of this particular building project: a one-way pitch roof; a late decision on placing ventilation tubes towards the narrow end of the roof (due to a specific placement of the roof hatch, which again is caused by a specific form of the stairway, that had to do with the design of flats, that is related to the need of the coming residents and the shape of the site); a discrepancy between the drawings of the architect and the engineer etc. According to the two experienced carpenters these particular interdependencies were unique to this particular roof. However, it is not at all unique for something unplanned to happen. In fact, the carpenters consider project errors to be an inevitable part of construction. As expressed by two of the most experienced carpenters in a discussion about the possibility of avoiding the double reconstruction of the roof houses:

“It would be nice if construction could be organised in a way where these kinds of problems did not take place. But it will not happen – for more than 30 years we have experienced the same kind of problems.”

In this case study, the problems in particular relates to the interdependencies between the carpenters constructing the roof house (A13 in the figure), making heads (A14) and erecting the rafters (A15), and the people installing the ventilation plant on the roof (A41) (figure 3). Firstly, these activities are characterised by many and mutual interdependencies between the two firms: the carpenters have to finish the roof house and rafters, then the ventilation people can install the

tube, then roof house and rafters have to be adjusted etc.²⁰ Secondly, interdependencies are strong (i.e. red arrows), as multiple interdependencies are reported.

This gives the coordination of these particular activities the following informational properties. Firstly, as only two firms and four persons are involved in producing these activities, the information regarding many actors is limited. Secondly, as the interdependencies are created by a particular combination of incidents, the degree of continuity is limited. And thirdly, the time spent searching and processing information on how to cope with the interactions of these activities is substantial, which implies a high activity complexity.

These particular interactions are interesting to study, as they give us an indication whether coordination modes change according to the informational properties of the activities at the overall level, as claimed in the theoretical part. More precisely, this combination – a few actors, non-repetitive interactions and complex activities – is expected to favour coordination by teaming. Thus, the remaining part of this section (6.2) will be devoted to an analysis of the coordination modes used for these particular activities and the reasons for why exactly these are used.

The use of teaming and authority in highly interdependent activities

In order to address this issue, the coordination modes reported by the carpenters and the ventilation people for coordination of these particular activities are compared with the overall coordination practices in table 5 and 6 respectively.

²⁰ As “each unit posing contingency for the other” (Thompson 1967, p. 55), the relation is reciprocal in the “Thompsonian” sense. This is not in conflict with the view, that the relation also can be perceived as a serial process: “There is, of course, a...serial aspect [of reciprocal relations] since the aircraft [the object chosen to illustrate the point] in question is used by one, then by the other, and again by the first.” (Thompson 1967, p. 55). What matters in order for the relation to be reciprocal is its two-way directionality, not that one thing is done before another.

Table 5: Coordination practices in the case of roof construction – values reported by carpenters compared with overall results (roof houses not included)

Coordination object	Who to conduct activity	When to conduct activity	Which materials to use	How much to produce	How it should look like	Which tools to use	How to do it	If quality is OK	What to do if in doubt
Coordination mode									
Authority 1 - Instructions from foreman	<u>4</u> 4 (3)	<u>5</u> 3 (2)							
Authority 2 - Instructions from clerk of works / management of firm	4,3 (3)	3,8 (5)	3 (2)	5 (1)		3 (1)			3,6 (3)
Authority 3 - Instructions from project management		2,6 (3)						<u>5</u> 3 (2)	
Authority 4 - Instructions from architects and engineers (e.g. drawings and instructions)		3 (2)	<u>5</u> 4 (5)	<u>4</u> 4,8 (7)	<u>4</u> 4,5 (7)		<u>2</u> (1)		
Pricing – Using the contracts signed when tendering took place.	4,5 (2)		4 (1)						
Teaming – Talking to other craftsmen, suppliers etc.	<u>2</u> 3 (2)	3,5 (2)		<u>2</u> 2 (1)	<u>2</u> 3 (2)	<u>2</u> (1)	<u>2</u> 3 (2)	5 (2)	3 (1)
Formal rules – Using general and written line of directions (e.g. instructions for use)				2 (1)					
Social norms 1 – By assessing the task and use my experience.			2 (1)			<u>2</u> 3 (2)	4 (1)	3 (2)	3 (1)
Social norms 2 – Not something I think about, I do as I always do.			4 (2)		4,5 (2)	<u>4</u> 5 (6)	<u>4</u> 4,8 (6)		
Other		5 (1)	3 (3)					3 (2)	3 (1)

The first figure (underscored) in each box represents values of coordination modes used for the activity of making the roof houses. If there is no figure in first line, this mode has not been reported. The next figure represents the average of all reported coordination modes (roof houses not included). The figure in brackets represents the number of observations (i.e. observations with the value of 2-5) including observations for roof houses.

Table 6: Coordination practices in the case of roof construction – values reported by the ventilation contractor compared with overall results (roof houses not included)

Coordination object	Who to conduct	When to conduct	Which materials to	How much to produce	How it should look like	Which tools to use	How to do it	If quality is OK	What to do if in doubt
Coordination mode									
Authority 1 - Instructions from foreman	<u>4</u> (3)	<u>4</u> (2)							
Authority 2 - Instructions from clerk of works / management of firm	<u>5</u> 4 (3)	<u>5</u> 4 (5)	3 (2)	5 (1)		3 (1)			3,6 (3)
Authority 3 - Instructions from project management		2,6 (3)						4 (2)	
Authority 4 - Instructions from architects and engineers (e.g. drawings and instructions)		3 (2)	4,2 (5)	<u>5</u> 4,7 (7)	<u>2</u> 4,8 (7)		2 (1)		
Pricing – Using the contracts signed when tendering took place.	4,5 (2)		4 (1)						
Teaming – Talking to other craftsmen, suppliers etc.	2,5 (2)	3,5 (2)		2 (1)	<u>3</u> 2 (2)	2 (1)	<u>3</u> 2 (2)	5 (2)	<u>3</u> (1)
Formal rules – Using general and written line of directions (e.g. instructions for use)				2 (1)					
Social norms 1 – By assessing the task and use my experience.			2 (1)			2,5 (2)	4 (1)	3 (2)	<u>3</u> 3 (1)
Social norms 2 – Not something I think about, I do as I always do.			<u>5</u> 3 (2)		<u>4</u> 5 (2)	<u>5</u> 4,8 (6)	<u>4</u> 5 (6)		
Other		5 (1)	3 (3)					3 (2)	3 (1)

The first figure (underscored) in each box represents values of coordination modes used for the activity of installing the ventilation plan. If there is no figure in first line, this mode has not been reported. The next figure represents the average of all reported coordination modes (ventilation not included). The figure in brackets represents the number of observations (i.e. observations with the value of 2-5) including observations for ventilation.

As seen in the tables, teaming is used to a low or medium degree concerning “how much to produce”, “finish”, “tools” and “how to do it”.

Here, the two activities outlined in table 5 and 6 account for all the teaming used.

However, in other areas teaming is not applied. In accordance with the general pattern, authority within the firm is used to delegate manpower, as well to time activities. Especially the latter is surprising, considering the high levels of time interdependence. Similarly, the architectural drawings are used to specify the amount of the work. So, even in some of the areas where teaming is used, coordination by authority is dominating, as seen by the reported values on the five point Likert scale. In an interview, the architect confirms the restricted use of teaming by reporting that he did not in any way make his instructions less specific for these activities.

In this way, the (albeit limited) use of teaming for these highly interdependent activities is not due to, but rather in spite of, the project management, the architect and others at the superior level. As remarked by one of the craftsmen doing the ventilation:

“I was supposed to use the drawings, but the drawings did not work [did not take into account that the rafters were too narrow at this part of the roof]. Then, ideally I was supposed to contact the project management in case of doubts, but that is too difficult. It is much easier to discuss these matters directly with the carpenters”.

This craftsman gets rid of the drawings after having observed how many tubes to install where on the first day. Instead of drawings, he uses his experience and, to a smaller degree, discusses with the carpenters. His superior is aware of this and also informally acknowledges, that deviations are made from the drawings. Yet, the craftsman does not think that his superior can get away without drawings due to the mandatory quality insurance system. However, an interview with a person responsible for this system at MT Højgaard indicated that this is not necessarily the case (Box 5).²¹

²¹ Even though the impact of the quality insurance system on coordination modes should not be overstated, the example is interesting. It stresses that coordination modes are not only a matter of transferring information from one part of the production process to another. It is also a matter of transferring and especially storing information to the benefit of the client. So even though personal discussion between the craftsmen in this situation perhaps is a superior way of transferring information about the finish of the work, it may not be superior taking the cost of storing into account.

Box 5: The quality insurance system and use of teaming

The quality insurance system was introduced in Denmark in 1986 as a systematic effort to reduce building defects. The system is mandatory for public or publicly supported building projects like, for instance, social housing. Private clients can use the system on a voluntary basis, which is quite common.

For each building project a quality inspection plan is carried out, specifying among other things, what to control, by whom the control should be made and when, the method used for inspection and the criteria used for approval. The main part of the control is carried out by the clerk of works or by the foreman, supplemented by spot-checking performed by the project management.

In principle, only the quality of the finished task is inspected, and as such there is no interference in the process used during construction, including the way the activities are coordinated. The results of the inspection have to be documented by drawings, text and/or pictures. Copies of the documents are handed over to the client upon completion of the project. Hence, provision of drawings and technical descriptions – for instance made as part of a tendering process or as instructions from architects and engineers – ease the process of carrying out the quality insurance system.

However, this is not to say that quality control excludes the use of teaming. This is seen in the case of the installation shaft observed at the same building site, as the roof case was conducted. (An installation shaft includes pipes for water, heating, sewage, ventilation, and electricity, including electric and water meters for each apartment. In Denmark, these installations are usually not visible in recent houses). Making the shaft is complex, because many different installations have to be fitted into a very small room. Not only should it be possible for each of the four trades (ventilation, plumbers, electricity and carpenters (making the shaft)) to get enough room to perform their part of the work, service personnel also need access in order to maintain installations and read the electric and water meters. In order to find out how to do this, the traditional pattern with the architects and engineers specifying the solutions is not used. Instead – by approval from project management – a mock-up (a 1:1 model of the shaft) is made in a process of negotiation and discussion between the trades involved. When the craftsmen agree on a solution, pictures of the mock-up are taken and the solution forwarded to the design consultants for approval.

But why then is teaming only used to coordinate these relatively interdependent activities to a medium degree and only for some parts of the activities?

A possible and with respect to the theoretical framework presented in chapter 3, very radical explanation would be, that it is possible to ensure a well coordinated state of these highly interdependent activities without the use of information intense methods.

Intuitively, the list of what the people at the site termed “errors in project” (see section 6.2.5) does not support this possibility. Even though these so-called “errors in project” were also observed on other parts of the roof, as well as on other parts of the building, it is remarkable that the majority of them (Ad A-E) are related to exactly those activities, where high interdependencies are observed.

Of course the presence of project errors is not a proof of a badly chosen combination of coordination modes. We do not know the number and size of project errors if other coordination modes were applied. And as described, project errors appear to be an inevitable part of any construction project. However, in a discussion of the possibilities of avoiding project errors, the carpenter spontaneously addresses the issue of coordination directly:

“Things works better on small projects like single-family houses, where the craftsmen talk together directly. This kind of conversation solves the problems like the ones with the ventilation tubes. On projects like this one, everything has to be passed on to the clerk of works, who has to pass it on to somebody else. Too much is lost in this process. Of course, the managers claim that this way of doing things reduces overall costs, but we have serious doubts if this is really the case.”

In general, all of the seven carpenters, with whom the issue of coordination by authority versus teaming was discussed, stress the importance of direct communication between the craftsmen. Or as an alternative, direct communication between the foremen (or a master working on the site, depending on the size of the firm).²² If direct communication is absent – for instance, if the architects or engineers specify too much – a lot of errors occur, because too much information is lost in transfer to higher levels. This is in agreement with the

²² This direct communication can take various forms. Some of the craftsmen think of direct interaction between the craftsmen out on the building site. Others have had good experiences with a daily half-hour morning meeting between the foremen.

observations done by a carpenter from the first team working on the project:

"We see a lot of things that project management or architects and engineers do not see. It ought to be mandatory for the project management to spend at least two hours daily out on every building site. Sitting there in their hut is not enough."

The crane driver expresses the same experience concerning how to hoist the windows:

"In general, it does not work very well when my boss agrees directly with the client about how to hoist the windows and which equipment to use. How to do things depends very much on a lot of things on site, so there is always something management does not take into account".

The perceived inadequacy of instructions by design consultants or project management has not only to do with the poor possibility of feedback from the building site. Even the information forwarded by the design consultants is not always coordinated, as seen in the example of the roof houses, where the position of the hole in the carcass was not coordinated between the architect and the engineers. *"Well, the architects can't think of everything. Mistakes are made"* as one of the carpenters puts it.

So why is teaming not used more often? And are the reasons, whatever they may be, inconsistent with the theoretical framework?

Again, let us turn to the explanations offered by the carpenters on this issue.

Independently, two of the carpenters mentioned, that it is very common to leave a substantial part of coordination to direct communication between the craftsmen on small projects. But for reasons not known by the carpenters, they observed that this form of coordination did not work on larger projects. However, chapter 3 has substantiated that teaming, due to number of communication links, is not very good at handling communication in large groups. And consequently, larger construction projects may be caught in a very difficult combination of low repetition, high degrees of interdependence and thus, high activity complexity. Since no coordination mechanism, or combination hereof, clearly reigns in this situation, the problems do not necessarily equal badly chosen coordination modes. Perhaps they simply illustrate that there is no easy

way to coordinate such a situation concerning the direct cost as well as the outcome (indirect cost) of coordination.

Another explanation often referred to by the carpenters is the piecework contract, where salaries are paid according to the output of each person or trade. Since each trade has no economic incentive to improve the output of other trades, it does not favour teaming. The problems especially arise while working under time pressure, where there is a tendency not to care about how other trades carry out their activities. For instance, building materials may not be removed, or solutions that trouble other trades' access to hidden installations may be carried out. Nonetheless, on several occasions it was observed, how the craftsmen actually paid attention to other trades, even though they were not contractually obliged to do so (and hence not paid for it). So even though the piecework contract does not result in totally atomised rent-seeking behaviour, its existence is a valuable reminder of the important interplay between information and incentive structures.

Thirdly, another explanation of the limited use of teaming, which comes to the mind doing observations on the building site, is something as simple as *lack of physical presence*. The seven different firms do not work on the roof simultaneously, they also work on other parts of the site, and on different projects. It seems obvious that this is an impediment to direct communication. To some degree, perhaps, the existence of project management can be understood along these lines: it is always present on the site in an easy to find place and hence it can act as a medium for people separated in time and place.²³ In the same vein, project management may also be seen as a way of reducing costs of monitoring scattered, with respect to the firm, employees. The coordination practises used for the people doing the roofing felt – where firm authority was present on the building site for other reasons – illustrates this point (box 6)

These three explanations clearly add some important insights to some of the difficulties of using teaming, even when interdependencies are strong. Yet, they do not seem to explain why we do not observe the use

²³ Of course, what makes such a medium required is the fact that the craftsmen do not know each other in advance and that often, people are only assigned to the job at the very last minute. If not so, other means of communication, like mobile phones, would most likely come into play.

of teaming in the coordination of interdependencies between roof houses, installment of ventilation plants and erection of rafters. With respect to the first explanation, two companies, with only two employees working on this job each, are involved. This number hardly oversteps the information capacity of a team. Concerning lack of incentives due to the pay-by-performance scheme, both parties reported that they had a lot to gain by adjusting their activities to each other. And indeed, both parties were present at the roof on the same time. Actually, a major part of the coordination problem was that they had to work on exactly the same spot of the roof. If nothing else, opportunities for direct communication were plenty.

Costs of identifying coordination modes

So the question still remains: why is teaming not used for these activities?

Now, teaming between carpenters and the ventilation people are in fact used, also concerning timing of events: not on the completion of the roof on the first apartment building, as was the object for this case study, but on completion of the identical roof on the second apartment building. To quote one of the carpenters, when asked about how he assessed the coordination of the activities in question:

“Well, on the second roof we did it somewhat differently. To follow the instructions from the management about the “rhythm” had proven far too difficult on the first roof. So together with the two people from the ventilation firm, we discussed and agreed on how to progress. Then we told the project management “we do it this and this way”, which they accepted.”

Box 6: The importance of physical distance? - the roofing felt case

As seen in the following table, the coordination of roofing felt activities differ from the general pattern with respect to the role of internal authority:

Coordination practices - Roofing felt (underscored) compared with overall results for roofing (without roofing felt)

Coordination object	Who to make task	When to make task	Which materials to use	How much to produce	How it should look like	Which tools to use	How to do it	If quality is OK	What to do if in doubt
Coordination mode									
Authority 1 - Instructions from foreman	4	4							
Authority 2 - Instructions from clerk of works / management of firm	<u>5</u> 4 (2)	<u>5</u> 3,5 (4)	<u>4</u> 2 (1)	<u>5</u> (0)		<u>3</u> (0)		<u>3</u> 5 (1)	<u>5</u> 3 (2)
Authority 3 - Instructions from project management		2,6						4	
Authority 4 - Instructions from architects and engineers (e.g. drawings and instructions)		3	4,2	4,7	4,4		2		
Pricing - Using the contracts signed when tendering took place.	4,5		4						
Teaming - Talking to other craftsmen, suppliers etc.	2,5	3,5		2	2,5	2	2,5	5	3
Formal rules - Using general and written line of directions (e.g. instructions for use)				2					
Social norms 1 - By assessing the task and use my experience.			2			<u>3</u> 2 (1)	4	<u>3</u> 3 (1)	3
Social norms 2 - Not something I think about, I do as I always do.			4		<u>5</u> 4 (1)	4,8	<u>5</u> 4,8 (5)		
Other		5	<u>3</u> 3,5 (2)					<u>3</u> 3 (1)	3

Brackets = number of observations, observation from roofing felt not included.

(Continues)

Box 6: The importance of physical distance? - the roofing felt case. Continued.

The use of internal authority for roofing is not restricted to allocation and timing of manpower only. Unlike what has been observed for other activities, firm management also instructs the craftsmen on materials, tools and quantity, and they do quality inspections and resolves doubts as well. In this way, internal management carries out a substantial part of the coordination otherwise performed by the project management or design consultants external to the roofing felt firm.

A potential explanation of these different coordination practises is the difficulty / importance of “welding” the roofing felt together correctly. If not done carefully, the roof is not waterproof, which in turn creates far-reaching damages and a costly repair (among other things, it is difficult to get access to the roof once the scaffold has been removed). Historically, there have been examples of bad workmanship in this area, and for this reason, the roofing felt industry in Denmark has struggled with a bad image. Hence, it has been mandatory for the industry to ensure a proper quality. As part of this, firms need to be certified and external firms – appointed by the roofing felt producers – inspect the quality (= the value of 3 in “other” / “If quality is OK”).

Perhaps for this reason, firm management and the supplier of building materials follow their employees much more carefully than construction firms in general. The two workers doing the roofing felt in the case study reported that their manager visit them at least a couple of times weekly, and sometimes comes around daily – undoubtedly the highest employee-employer interaction observed in the roof case.

Once the firm management is present on the site, it becomes obvious for them to also to engage in coordination of objectives – like for instance how much to produce - not strictly associated with the quality of the product. Hence, the coordination practices observed for roofing felt not only reflect how coordination practises differ with respect to the sensitivity of correct working procedures. They also inform us what coordination practices might look like, if the importance of physical distance was reduced (as it is for spatially fixed production).

The quote clearly gives credence to the importance of including costs of *identifying appropriate coordination modes* in order to understand the selection of coordination modes. No one, not even the craftsmen, knows the true value of the interdependencies for this particular kind of roof. Of course, they have some ideas from previous projects, but there are always small variations in the roof and hence, variations in interdependencies. This roof turned out to be difficult due to a set of conditions particular to this project (a one-way pitch roof; a late decision on placing ventilation tubes towards the narrow end of the roof etc.).

Consequently, in the outset it is costly to obtain the information necessary to choose appropriate coordination modes.

Then along the way, interdependencies (and various problems) are revealed, which, at least ideally, paves the way for a revision of the coordination modes applied. The story is essentially a Smithian one: by repetition, persons can increase their dexterity not only in carrying out activities, but also in coordinating them. And, it appears, in the long run, the story is also very consistent with the theoretical framework developed in chapter 3. In the beginning, there is not the anticipated relation between interdependencies and coordination modes – and hence, rather than having coordination modes fine-tuned to these interdependencies, robust patterns are applied – but as people learn, coordination modes and interdependencies come into agreement.

Unfortunately, with respect to construction there are some “thorns” in this story. First and foremost, the same activities are not often repeated. In the roof case, two identical roofs were constructed and the people could learn from this. But they could only learn from the many roofs each of them had partaken in on previous projects to a limited degree. Secondly, there are also organisational reasons why construction is not conducive to learning about coordination modes. For instance, the circulation of personnel within and between building sites reduces the impact of delays, but at the same time may limit the learning obtained by, say, two identical roofs. Furthermore, as discussed in the chapter that follows, coordination by a third party, i.e. an external firm, renders incentive problems likely. To push it to the extremes (and far beyond what was actually observed in the case study): why should project management or design consultants spend extra resources on coordination to make life sweet for subcontractors? Even if project management does care, it is probably much more difficult to learn from, and teach to, people they do not know due to ever changing working constellations. At the craftsmen level, the same examples apply: the pay per performance system potentially creates problems of sub-optimising behaviour, and changing working constellations makes investment in firm- and person-specific learning less attractive.

In balance, the interaction between carpenters and the people doing the ventilation illustrates the importance of including costs of identifying coordination modes in order to understand why certain coordination

modes, and not others, come into play. As argued, this conclusion is particularly important to have in mind when studying cases where repetition is limited. In construction, among others changes in demand reduce repetition and the emergence of long-lasting relations. Change in the taste of customers or technological development may spur the same situation, hence making the observation from this particular case relevant to a larger empirical field than simply construction.

Robustness in coordination modes

The costs of identifying appropriate coordination modes, as discussed in the previous section, imply that in order to save on these costs, coordination modes are not necessarily fine-tuned to interdependencies. In this perspective, it can make sense not to coordinate the interaction between the carpenters and the ventilation people by teaming, even though their activities are highly dependent on each other.

The question then is how “robust” the general coordination pattern is: is it always the same, or will it be affected by differences in interdependencies if these are sufficiently large? Two observations made in connection to, but not directly on, the case study seem to support the latter position.

The first observation is the installation shaft referred to previously (box 5). As this example indicates, teaming between the craftsmen (and perhaps also between the craftsmen and the design team) is to a higher degree used here, than in the general pattern of coordination observed for the roof case. Interestingly, in an interview with the project manager, the installation shaft was pointed out beforehand as the part of the building, in which interdependencies were strongest. In line with the cost-of-identification-explanation of the selection of coordination modes, this suggests that different coordination modes when activities are more (or less) interdependent than usual AND when this is known ex ante production.

Perhaps coordination modes used for refurbishment are a second example of the fact that even though coordination patterns were found to be rather robust in roof production, they were not indifferent to interdependencies (box 7).

Box 7: The widespread use of teaming in coordination of refurbishment projects

Refurbishment is interesting from a coordination point of view, since activities are reported to be more interdependent than in building of new houses. Due to the high costs of specifying the condition of the house subject to refurbishment *ex ante*, the exact procedures and the way trades interact are very difficult to foresee. According to the theoretical framework, due to the higher degree of interdependence, we would expect to find other modes of coordination in play.

One of the craftsmen reported the use of the following coordination modes during refurbishment:

Craftsmen – level	Who to make task	When to make task	Which materials to use	How much to produce	How it should look like	Which tkools to use	How to do	If quality is OK	What to do if in doubt
Coordination object									
Coordination mode									
Authority 1 - Instructions from foreman	5	5	3	4	4				
Authority 2 - Instructions from clerk of works / management of firm			3	4	4				
Authority 3 - Instructions from project management			3						
Authority 4 - Instructions from architects and engineers (e.g. drawings and instructions)				2	2				
Pricing - Using the contracts signed when tendering took place.									
Teaming - Talking to other craftsmen, suppliers etc.			3	4	4		4		
Formal rules - Using general and written line of directions (e.g. instructions for use)									
Social norms 1 - By assessing the task and use my experience.			2				2		
Social norms 2 - Not something I think about, I do asI always do.						5			
Other			2						

The observed modes are in line with the theoretical expectations in the sense that teaming is used more forcefully for more coordination objects than in the roof case. Besides this, the observed patterns seem to support Thompson's view, that the more interdependent activities are, the wider the range of coordination modes used.

The payment system is also different from what is usually observed in construction of new houses. Instead of piecework contracts, payment is normally based on a rough estimate of any task; that is, the master estimates the number of man-hours needed for a task and gives a sum of money to the carpenters. If there is money left, this is a bonus for the carpenters. However, the relation between the master and client is not different. A contract specifying the extent of the work is signed, and if the actual work exceeds this contract, the master makes claims.

6.3 Exit – an illustrative example of activities and coordination in a repetitive setting

So far, coordination has been studied in an environment with low degree of repetition in the activities carried out by a single person, by a firm or in an interfirm arrangement. It has been shown how this enforces a particular balance between production and coordination costs, between costs of coordinating and costs of not being coordinated, and between costs of creating, using, and identifying coordination modes.

For the purpose of illustrating the impact of repetition, furniture production seems ideal in a number of dimensions. In a Danish context, construction and furniture production share many features²⁴, but they vary with respect to how many times the same product is produced, as well as with respect to the existence of long-term interfirm relations. Hence, let us conclude this chapter on coordination in the construction industry by broadening the horizon and seeing what can be learned about selection of coordination mechanisms in a non-construction setting.²⁵

²⁴ Both construction and furniture production take place in (a) mature industries in which (b) Denmark has a reputation for performing well internationally (c) partly due to unique design skills; (d) they both produce physical objects, thus transportation and distance matters (irrespectively of new information technologies); (e) production is often ordered and in small batches; (f) skilled craftsmen constitute a significant part of the people employed and consequently, the educational background is to a high degree the same; (g) to some degree they work with the same materials and tools, in fact quite a few companies shift between production of furniture and construction components; (h) the regional setting of production is partly overlapping (since construction on at least site-level takes place all over the country); and (i) they are, in general, both subject to the same external conditions constituted by legislation and government policies.

²⁵ The case study on sofa production presented here is conducted as part of a LOK research project carried out in collaboration with Mark Lorenzen. Data has, as in the roof case, been collected in spring 2001 by a combination of observations and semi-structured interviews. As it will be seen, in sofa production, each activity is ongoing, routinized, and known by the management. Consequently, it was possible to collect the required data in a two-day period, starting with key-informant interviews supplemented with short interviews with employees. We relied on existing empirical data on the firms (from Lorenzen 1999), and spent 20 hours on interviews and observation in two furniture firms in the Salling district. The interview/observation started out with a guided tour by the production manager or similar, showing the flow of activities. This provided a general overview, which in turn allowed for very focused interviews with individual employees.

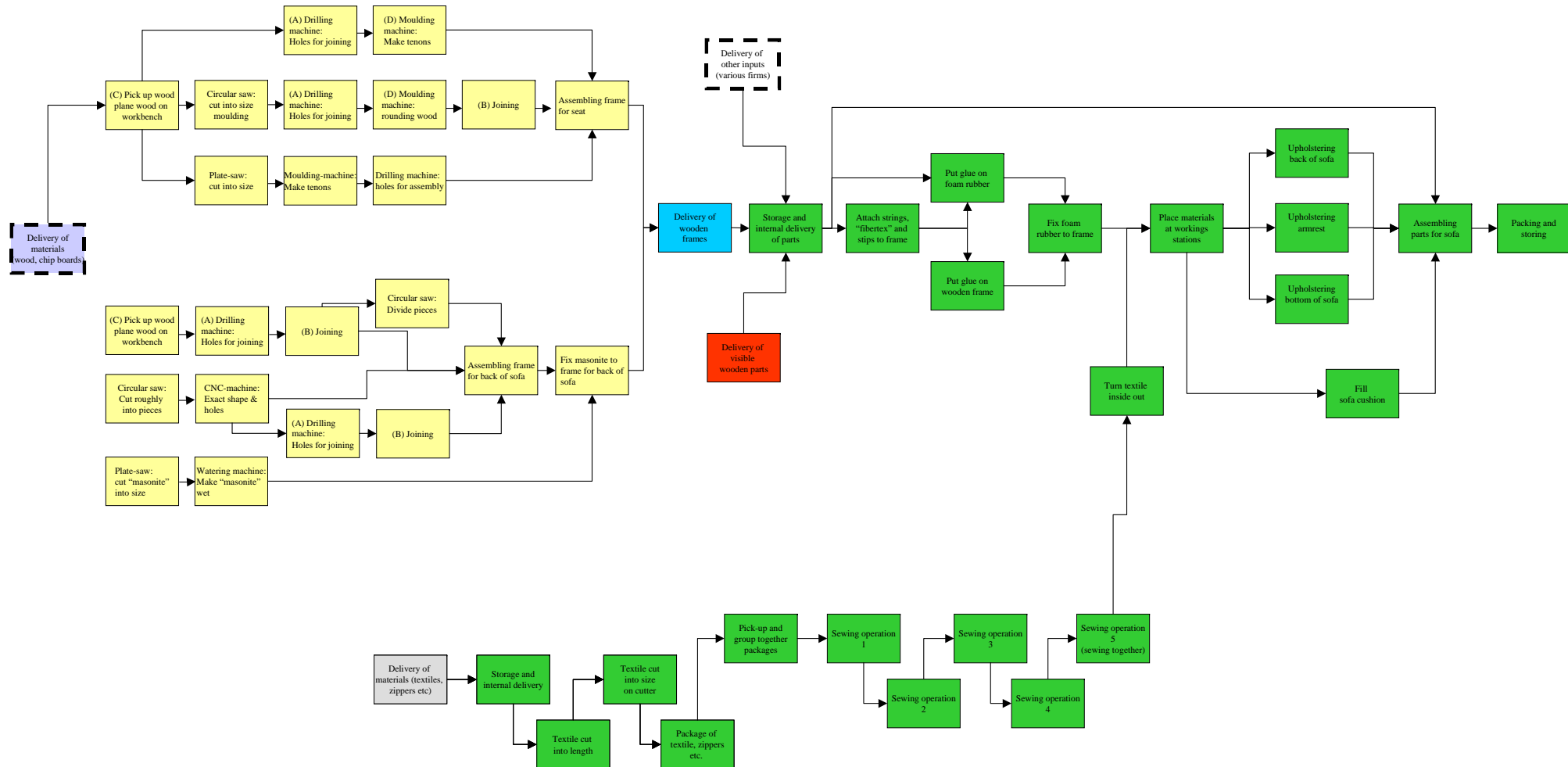
To come up with the conclusion, on the one hand the sofa case supports the idea, that interdependencies and coordination modes are associated. But in some very crucial aspects the story is very different from the one offered in particular by Thompson and the contingency approach. First of all, coordination modes are not adjusted to (the interdependence) of activities. The causality runs exactly the other way. Rather than changing coordination modes, the activities are defined in a way so that interdependencies are low. Secondly, due to learning it is possible to handle rather interdependent relations with “information light” coordination modes. For instance, a sequential relation can be handled by standardisation (and not planning as Thompson proposes).

The outline of this section is as follows. Firstly, the activities involved in sofa production are presented, then it is described how they are coordinated and finally, it is discussed why these particular mechanisms come into play.

6.3.1 Activities in sofa production

The activities involved in sofa production are illustrated in Figure 4.

Figure 4: Activities in sofa production



Compared with figure 2, there are some obvious differences between sofa and roof production.

First of all, it is evident, that even though the number of man-hours spent on making a roof outweighs the number of man-hours spent on making a sofa, sofa production consists of at least as many activities. This, of course, has to do with a more extensive division of labour.

Further, the ways colours (each colour representing a firm) are distributed in the two figures inform us of large differences in the role of the firm with respect to coordination. Sofa production is organized in sequences of activities located *within* two firms and hence, a substantial part of coordination takes place within the firm. In roofing, more firms (seven) are involved in production and what is more, they do not perform their activities in succession. This implies a much higher level of *interfirm* coordination.

And finally, sofa production is more modular concerning time interdependence, since the activities are organised as multiple streams rather than as a simple line of strings (as, roughly speaking, in the roof case).

6.3.2 Coordination in sofa production

As it would be expected from a learning based approach to coordination, the pattern of coordination changes as a sequence of activities is repeated.

When a new batch (i.e. type of sofa) is launched, management spends extensive efforts manufacturing the information needed to produce templates and instruct workers on exactly how to do the job.²⁶ In the

²⁶ In firm A, this work is conducted entirely by the manager-owner of the firm. In firm B, the process is the following. When an idea is accepted, a prototype is sketched out. Based on this, the management splits the prototype into different working operations, which allows a first test batch to be produced. The head of each of the three departments in which production is divided, closely follow this process, writing down problems or potential improvements. After the test batch, a meeting is held with the heads of departments and one representative from sales and purchasing respectively, in order to revise working procedures. If revisions are made, a new test batch is produced, and if everything works out, the series is put into production. Usually, two or three test batches are produced. This is in

development phase, teaming and negotiation is used at the management level, and authority at the level of the employees.

Later, when production of a series is well tested and becomes routinized, management only contributes to the internal process of coordination by giving notice on when to produce which batches and providing deadlines, that is, deciding which customers to satisfy first. The employees work predominantly by standards and routines, that is, processes where little information transfer is needed. In this part of the process, the only instances where information transfer is upgraded, is when management steps into change the work sequences, in order to accommodate specific, urgent needs of customers. This was particularly relevant for the activities undertaken by firm A, the smaller supplier of wooden frames, having a range of different customers.²⁷ In order to cope with urgent deliveries, management shuffles around orders, which in turn makes it necessary for the foremen to adjust which activities they work on in the different parts of the value chain. Consequently, the foremen — especially in busy periods — spend some time discussing which of the many ongoing production activities to put at the top of the agenda.

Hence, for well-known sofa types, a substantial part of the coordination is undertaken by structuring the work in a sequence of work stations within the two firms — the supplier of wooden frames (firm A), as well as the end producer of sofas (firm B). In both firms, each work station uses a specific machine and — depending on the batch — a specific template. Allocating activities to specific work stations allows for coordination by routines, concerning *whom* to do the activity and obviously also which *tools* to use. In combination with the template made by the foreman or manager, the tool also structures *how* to do the job to a substantial degree. Which *materials* and how much to produce (*extent*) to use is very much given by the input from previous activities, since the activities where new materials are added, are rare.

agreement with the experience in firm A: it usually takes two or three tests before everything runs smoothly.

²⁷ Firm B mainly produces according to the sequence in which orders are given. Where the foremen in firm A ensure deadlines, a computerized system keeps track of progress in firm B. Each employee types a four-digit code for each operation completed.

Structuring the work around a defined sequence of activities further provides some information on *when* to do the activity, since the workers simply process the input provided to them. Instructions from the management on this matter is consequently limited to initiating the batch. Management also decides on which deliveries to make when. In this way, information on when to do the activities flows two ways. It flows forwards, since the output of one activity is the input of the next. And it flows backwards, since the foremen are responsible for making sure that deadlines for outbound deliveries are met. In case the foreman in the assembly part (i.e. at the end of the value chain with the end producer of sofas) discovers delays, in agreement with foremen upstream, manpower is allocated to bottlenecks. The specific form of the reallocation varies, depending among other things on the machinery. For machinery that demands personnel with little training, most persons can be reallocated, whereas only experienced personnel or skilled workers — very often the foremen — are used for more advanced machinery.

Doubts are almost completely solved ex ante production, as the templates and the given sequences of working stations render few contingencies unforeseen. *Quality control*, on the other hand, is required, which to a high degree can be explained by deviances in input; in particular, the quality and colour of leather products can vary. Quality control is not done by management or third parties, but follows from the set-up of activities in a sequence: in most cases, defaults will be identified immediately by those carrying out the next activity.

An interesting feature of coordination in ongoing sofa production is its reliance upon shared knowledge and knowledge embedded in machinery. This is made feasible by the recurrent nature of activities, and their integration into only two firms. Within these firms, little information is transferred directly between persons — not only because standards and routines govern actions, but also because information is embedded in how the products move along the value chain (in firm B, the information on how to carry out the activities in the sequence is printed on a production note that is stapled to each product). In daily operations, the role of management for coordination seems limited. But as described, it is management that “hardwires” coordination into machines, prescribing working procedures (i.e. activities), and fixing

relations between working procedures. Hence, the role of indirect management is large.

To recall, the opposite is the case in construction. Because of the nature of activities and their disintegration into a large number of firms, routinization and hardwiring of coordination cannot take place to a degree similar to the sofa production case. Relying on the skills and routines of single entrepreneurs,²⁸ but not encompassing routinization of coordination or impersonal management of the kind found in the sofa case, roof production is based on authority provided by personal management.

Some of the main (and interrelated) differences in the way sofa and roof production are coordinated, are summarised in table 7.

²⁸ This corresponds well with the observation, that in the roofing case only skilled carpenters were used for carpentry work, whereas more workers in the sofa case were unskilled.

Table 7: Main differences in the coordination of sofa and roof production

	Sofa production (Repeated production)	Roof production (Non-repeated production)
The distribution of a firm's activities in the value chain	A firm carries out a continuous row of activities.	A firm carries out activities "here and there" in the value chain.
Coordination and firm boundaries	Unilateral and bilateral coordination.	Bilateral and trilateral coordination.
The firm as coordinator	The sofa firm coordinates between value chains and within the single value chain.	The construction firm coordinates mainly between value chains. The general contractor and design consultants mainly coordinate within the value chain.
Type of authority²⁹	Impersonal authority.	Personal authority.
Carriers of information	Mainly flows of materials.	Mainly personal communication.
Kind of standardisation	Standardisation of skills, physical input, tools and working procedures.	Standardisation of skills and output.
Degree of variability in activities	Low degree of variability in activities.	High degree of variability in activities.
Applicability of skills	Very specialised skills (to suit only a few activities).	Widely applicable skills (to suit a wide range of activities).
General educational level of workers	Mainly unskilled.	Mainly skilled.

²⁹ The distinction between impersonal and personal authority is from Arrow (1974), who describes impersonal authority as working through codes of conduct which prescribe what each member of the organisation is to do under a variety of possible circumstances. Personal authority is the giving and taking of orders.

6.3.3 Coordination modes and interdependencies

As expected, more resources appear to be devoted to identifying and creating appropriate coordination modes in the repetitive production of sofas, than in the less repetitive roof construction. For example, when new products are introduced, the management of firms A or B devote their resources to finding out, how to produce and coordinate sofa parts, or sofas, respectively. In turn, these considerations are transformed into standards and routines, where information is inherent in the product flow and the given structure of workstations.

However, these resources pertain to the division of labour more than to coordination mechanisms. In fact, coordination mechanisms seem rather stable. Rather than developing more and more fine-tuned coordination mechanisms, these producers reduce the complexity of coordination by simplifying activities. Hence, they reduce the amount of information to be transferred. In this way, even activities that in the outset are different, can come into agreement with a simple coordination scheme — reducing not only the information need in coordinating production activities, but also eliminating the need for further experimentation with new coordination mechanisms. Efficiency of learning — within, as well as across firm boundaries — leads to a change of division of labour, while maintaining a rather narrow spectrum of coordination mechanisms, and not too many fine-tuned mechanisms adjusted to particular interdependencies.

It is notable, that a high level of learning has a positive impact on efficiency. Through such learning, even activities that first may require substantial transfer of information can later be coordinated by information-cheap means, such as standards and firm-routines, as provided by the flow of the product and a given structure of work stations. Hence, activities may have a very high degree of interdependence and at the same time require little interpersonal communication.

It also refines the view on division of labour as the cause of coordination. Undoubtedly, little, if any, coordination would be required, if there was no division of labour. But as seen in the case of sofa production, by splitting up production in very delimited activities, it becomes easier for management to provide and implement a full description of how to

carry out the activity. Hence, increasing the division of labour on the one hand creates a need for coordination, but on the other hand also enables the use of means, for instance well-described working procedures, by which the job of coordination can be made easier.

SUMMARY ON EMPIRICAL PART

In combination with the theoretical speculations offered in chapter 2 and 3, the empirical observations found in this and the previous chapter offer elements to a story of why construction is organised and coordinated the way it is. Let me conclude this chapter by presenting the puzzle in a less detailed version than the one presented on the many pages above.

Lack of repetition due to market fluctuations play a key role here. Other sources to lack of repetition have been identified, for instance variations caused at the micro level by the particularity of the building site or client demands, by discontinuity of the project team and firm-relations etc. Yet, it has been argued that these variations to a large degree is a consequence of, or is amplified by, market fluctuations. Therefore – and in order to keep the story as simple as possible – I will try to maintain market fluctuations as the single independent variable in the following line of reasoning.

Due to unstable markets, the process of construction faces a low level of repetition at the macro level. This inflicts a high degree of novelty to the building process, as firms, individuals, the exact activities and their interdependencies differ from one project to another in spite of the fact that final products are not necessarily very different and that the technologies employed appear to be very stable. The non-repetitiveness at the macro level is a key to understand the division of labour, the organisation of coordination and the coordination modes used in the process of construction (the three research questions).

The overall market changes propagate to the level of firms, thus making it more important for construction firms to be adaptable than to be specialised. Hence, construction activities are usually not internalised in a long string of activities carried out by a single firm specialised in producing a particular kind of building (for instance housing) or even a sub-set of a building (for instance a roof). Neither are construction firms engaged in long-term interfirm relations where firm or inter-firm specific capabilities are developed. Instead, construction firms carry out very delimited sets of activities “here and there” in the value chain with counterparts which at the level of the individual (and often also at the level of firms) are replaced from one project to the next.

In this set-up, a trade system - in which employers and their employees are grouped together according to their capabilities in trades like carpentry, plumbing etc. - holds the following advantages. Organising the work in trades allows for a degree of specialisation that is higher than in the “jack-of-all-trades” firm. At the same time, as firms within the same trade are identical to each other due to the skills and working procedures provided by for example the apprentice system, one, say, carpentry-firm (or carpenter) can be replaced with another with minimal impact on the operations of other firms. Thus, by having these sector-wide interfaces, coordination costs are lowered substantially in a set-up, where overall fluctuations in demand make relations between specific firms and individuals costly to maintain. In this way, the lack of repetition at the levels of individuals and firms are to some degree replaced by repetition at the level of trades. The shared expectations towards the behaviour of other firms and individuals not known from prior working relations are further supported by a wider institutional framework: an industry-wide piece rate system, a quality insurance system, a court of arbitration, standard contracts between client and contractor etc.

At the same time, by not being too specialised, it is possible for firms to engage in many different working constellations, not only between building projects, but also within the single project. This makes it possible to shift around the sequence of activities undertaken by the firm, and hereby adjust to the delays that easily arise because working procedures are not entirely routinised, and because input to a substantial degree is processed on the site and hence, cannot easily be stored or substituted.

In balance, the trade system gives away some of the benefits of being very good at one particular activity in order to gain on lower *coordination costs* and, other things being equal, lower production costs stemming from less unused production facilities. Accordingly, even though the trades have long historical roots and most likely were created in a setting that was very different from that of today, it may be in the interest of the parties involved in construction to maintain this system.

So far, the effects of changes that can be traced back to the macro level have been discussed. But sources to variations can also be found at the micro level. There are often small variations due to the wishes of the

client (or the architect), the particular shape and position of the building site, zoning laws etc. Yet, if not for change in overall demand, presumably identical strings of activities could be repeated by the same firm, or group of firms, specialised in a certain segment of the market. For instance, a firm could specialise in execution, and in turn perhaps also planning, of a one-way pitched roof on medium scale buildings.³⁰ But as specialisation – and consequently also the development of modular designs and products – is hardly an option, variations in the final product cause variations in the working processes.

Since each project is new for the involved parties, successful coordination cannot be achieved by following past behaviour more or less unconsciously. Planning is one way by which construction tackle the issue of coordination in a deliberate manner. By providing timetables and output specifications, some agreement between the actions of all the separate actors in construction is reached. In particular, it is a way to ensure, that the final product is consistent with the specifications of the client. However, the benefits of a well-planned process (i.e. the benefits of having information) have to be balanced with the costs directly involved in making them (i.e. the cost of getting information). Here, the low level of repetition pushes the point of balance towards a rather unplanned building process, as plans cannot be reused by the involved parties (even if it is assumed that all information, at costs, can be acquired for a new product ex ante production).

Correspondingly, robust patterns of coordination modes are used. As these patterns are not adjusted to variations in informational requirements, they do not minimise on the *costs of using* coordination modes; in particular not when new building materials and technical solutions or unfortunate coincidences complicate interactions locally and thus call for decentralised decisions by teaming. However, the stable patterns reduce the *costs of identifying* the best of coordination modes –

³⁰ From an interdependence perspective, it seems that roof activities constitute a cluster of activities. Only a few of the interdependencies shown in figure 3 in this chapter relate to activities on other parts of the building than the roof: making the site accessible (A21), bricklaying of facing wall (A32), putting up scaffold (A43, also used for bricklayers), and to a limited degree installing of the vertical ventilation tubes (a41). This gives reason to wonder about the possibility of integrating all activities on the roof into a single firm.

again, costs that are important to consider in construction due to the low level of repetition.

As activities are different from one project to another (even though they may look alike with respect to the result) and as planning is far from perfect, the acceptance of many unforeseen events (“project errors”) and ad hoc adaptability to new situations is an important – and presumably often also efficient – way of handling coordination in construction. This in turn makes it costly to use input, tools and working procedures, which due to their limited flexibility in a very clear way instruct construction workers how to perform the activities. The implications of the limited use of these “behaviour-guiding structures” are threefold.

First, the use of *craft* production: the complexity of the activity becomes substantial which in turn requires the use of skilled workers, who can decide locally which tools etc. to use. So besides being grouped together in trades according to their capabilities, construction workers are generally well-educated from the beginning of their career (at the other hand, due to high personal mobility, the continuous training of construction workers is probably limited; a conjecture that also could explain the limited seniority-related increase in salary within construction).

Secondly, building materials that are not yet cut into size or assembled for final use are by far the most dominant in construction. The low level of prefabrication implies that a lot of value adding takes place on the building site. This ensures flexibility, but again reduces some of the benefits of the division of labour and large-scale production, as production on the building site obviously amounts only to the needs of that particular site. Furthermore, the physical co-production on site makes the complexity of each activity even larger, due to interdependencies concerning access and damage.

Thirdly, as information, over time, only to a limited extent becomes incorporated in procedures or routines, or in the materials or tools used, coordination requires that substantial resources and particular skills constantly are devoted to processing and distribution of information. In combination with the limited potential for coordination within a firm or bilateral coordination between two firms, this paves the way for persons and firms specialised in coordination (and in turn creates a concentration of academics in firms of architects and engineers). Two types of such

firms engaged in trilateral coordination are observed in construction: the firms belonging to the *design team*, who mainly works with planning prior to construction, and the *project management*, who facilitates ad hoc adaptation during construction.

Thus, with respect to coordination as observed at the level of the craftsmen, the following characteristics are central to construction. Firstly, even though plans, timetables and descriptions are made *ex ante* production, a substantial part of coordination is done by ad hoc adjustment during construction. In the interpretation given here, these ongoing adjustments balance the costs of not having information with the costs of getting information in a non-repeated setting. Secondly, coordination is partly done by centralised decisions (e.g. on the allocation of manpower and the outcome of an activity), partly done by decentralised decisions (e.g. on which tools and working procedures to follow). Consequently, each activity is coordinated by a particular combination of multiple coordination modes. This observation seems consistent with the theoretical claim, that no single coordination mode can handle the information involved in non-repeated, complex activities with many actors potentially involved (as information on interdependencies is costly to provide in advance for novel activities). Thirdly, presumably due to high identification costs in the non-repetitive setting, these coordination patterns are rather robust, in the sense that they are not fine-tuned to the interdependencies of the activities (but are not “immune” to different levels of interdependencies either). Finally, as a sign of trilateral coordination, the craftsmen receive instructions on how to perform their work not only from superiors within their own firm, but also directly from design consultants and project managers in external firms.

Chapter 7 – Theoretical perspectives

...on the division of labour and knowledge, specialisation in coordination and the firm as a coordinator, and the efficient application of coordination modes in temporary organisations

7.1 Introduction

The interaction between theory and empirical observations is mutual. As hopefully seen in the previous empirical chapters (and the following chapter 8) theory can facilitate an interpretation of complex and otherwise hardly comprehensible phenomena. However, empirical observations also add new insights to theories through the support, deepening, complementation or contradictions they provide. The latter aspect is considered in this final chapter. Rather than going through the theoretical framework as presented in chapters 2 and 3 meticulously, I will focus on the areas in which contributions to the theoretical framework appear to be most profound in the light of the empirical findings presented in chapters 5 and 6.

In order to stress that the discussion and suggestions offered in this first section of the chapter point towards *analytical generalisation*, the claims I make are formulated as three *propositions* (and not final conclusions). The propositions are organised according to the three main research questions.

To recall, the first question relates to the division of labour in construction (the *why*-question). At a more general theoretical level, this question may inform us of scope and limits to the *division of labour* in situations with little repetition of sequences of activities. The observations offered in this thesis suggests the following

Proposition A: The less repetitive sequences of activities are, the more individuals and firms are driven towards isomorphism rather than innovation and specialisation. Thus, the less repetition, the lower the level of overall innovation and the higher the ratio of systemic innovation.

The second question relates to *specialisation in coordination*, and the role of *the firm*¹ in the process of coordinating activities (the *whom-question*). An important sub-question here is why activities and coordination of activities in some situations are fixed in repetitive relations and in other situations interact on a more temporary (and interfirm) basis. This thesis suggest the following:

Proposition B: Low levels of repetitive sequences of activities increase the ratio of coordination done by a third party firm (trilateral coordination), but decrease coordination organised directly between two firms (i.e. bilateral coordination) or coordination organised within a firm (i.e. unilateral coordination).

The final research question concerns the information costs of different coordination modes and why, in an information perspective, certain coordination modes are chosen for a given situation (the *how-question*). The proposition is as follows:

Proposition C: The more repetitive sequences of activities are, the more coordination costs are lowered due to not only to (I) lower costs of identifying appropriate coordination modes but also as an effect of (II) lower costs of using a given coordination mode, and (III) lower costs to defining activities in a way that they become easy to coordinate.

The propositions provide a synthesis of how the empirical observations made within roof and sofa production contribute to a review of the theoretical framework presented in chapters 2 and 3. In the following sub-sections, I outline the stylised facts and (information and incentive based) reflections, which provide the foundation for, or follow from, these propositions.

As the propositions and specific insights are based on (analytical) generalisation of findings made within a particular empirical setting, they should be treated as propositions and nothing more: claims about

¹ The firm is here both understood as a set of resources and activities and by its legal and contractual boundaries.

causal relations to be confirmed or rejected by further empirical studies. Acknowledging that design, not to say implementation, of such additional empirical inquiries is far beyond the scope of the present work, it is my hope that the propositions offered here may inspire others.

In particular, I hope that the propositions inspire other to probe into how different kinds of change affect economic organisation. As pointed out on several occasions, *repetition* – not only in a single activity as Adam Smith (1970) focuses on, but also in *sequences* of activities – is a key to understand the division of labour, the organisation of coordination, and the selection of coordination modes. In construction, change in *overall demand* has been pointed out as a particularly important source of a limited scope for repetition of sequences of activities. Yet, it is possible to think of other sources of low degrees of continuity; for instance (a) change in costumers preferences; (b) technological development allowing new manufacturing principles and products; or (c) change in seasons or supply of raw materials (Stinchcombe 1990). It could be conjectured, that the effect of change in these three dimensions will have the same effect, or at least *some* of the same effects, as change in overall demand: they make it less favourable to establish repeated sequences of activities. If so, the propositions offered here will be valid to a larger set of economic activities than construction and could be part in a more general framework on why temporary organisations (or *project* organisations) behave differently from less temporary ones.

7.2 Proposition A - Perspectives on specialisation and the division of labour and knowledge in temporary organisations

Even though Adam Smith was not at all ignorant of the limits to the division of labour, he primarily provided a compelling argument for why *dissimilarity* is in the interests of individuals and society. Drawing on Becker and Murphy's (1992) basic idea, that low production costs obtained by the division of labour and specialisation have to be balanced with coordination costs, this thesis points to the benefits of *similarity* (or *isomorphism*). More precisely, what is suggested in proposition A is that when interactions in activities are not frequently repeated, the benefits firms and individuals can gain from being similar, tend to outweigh the benefits of being dissimilar.

7.2.1 The importance of isomorphism rather than specialisation

Thus, at the overall level, the empirical observations (and hence proposition A) do not contradict the fundamental trade-off between the division of labour and coordination costs. However, the coordination practices found in construction and furniture production respectively, illustrate how important repetitiveness is for the exact point of intersection between, on the one hand, advantages from firm specific innovation and specialisation and, on the other hand, lower coordination costs due to isomorphism.

In the case of sofa production, repetition of working constellations and activities encourages that employees focus on a very delimited and defined activity, which over time become standardised and routinised, and accordingly, coordination costs are low. Conversely, the division of labour is more limited in construction due to higher coordination costs and the importance of adaptability to new market situations. However, the number of different activities (concerning, materials, working procedures, tools etc.) are substantial in construction and do not favour a “jack-of-all-trades” solution. The existence of *trades* – in which firms and people with identical knowledge, skills and experience are grouped together – is a way of accommodating the need for lowering the costs of coordination and inflexibility in a non-repetitive setting, and at the same time to allow some division of labour to take place.

An important role of organising in trades is to create *shared expectations*. Firms and individuals that do not know each other from previous interactions know what to expect, as firms and individuals within a trade behave identically.² Thus, the more general lesson suggested in proposition A is that in industries where long-term relations due to rigidity are costly to maintain, it is in the interest of firms and individuals not to break away from an *isomorphic* way of organising (e.g. the trade-organisation), as this would limit their ability to shift to new working constellations.

² The surgery team conducting an operation or the crew of people producing a movie may represent features similar to that of the trade organisation in construction: in each project (i.e. operation/movie) a number of very specialised, but identical from one project to another, professions are involved.

With respect to indicators showing the (in)correctness of proposition A, we would expect to find that in industries with limited duration of interfirm or interpersonal relations, (non-specialised) firms and individuals that behave according to the rules and norms of their respective trades, will outperform (specialised) firms and individuals that deviate from the trade behaviour. Further, if the need for flexibility is dependent on overall market trends in such a way, that working constellations are more easily maintained in periods with stable or increased demand, it should be expected that the ratio of successful specialised firms is higher in periods with stable or increasing demand, than in periods of decreasing demand. In connection with the statistical inquiries presented in chapter 5, it was attempted to bring supplementary evidence on the benefits of isomorphism by looking at the survival rates of specialised versus isomorphic firms in construction. Unfortunately, it was not possible to locate such specialised firms.³

As discussed in the next chapter, limited benefits of specialisation are likely to have implications for the level and type of innovations as it favours systemic innovations rather than autonomous firm innovations. This in turn creates particular selection mechanisms (i.e. the mechanisms by which the less successful firms are sorted out from the more successful ones).

7.2.2 Limits to isomorphism

The study has empirically illustrated, how lack of repetition between specific individuals and firms is replaced by *repetition at a more aggregate level*, i.e. repetition among isomorphic groups (e.g. trades). Yet, repetition at these two different levels has not been found to be two of a kind with respect to the division of labour. The degree to which activities could be repeated in exactly the same way, appears to be much more profound in sofa production than in roof production. The “lack” of innovations in

³ More specifically, the idea was to see whether firms that had a special educational profile (e.g. carpentry firms that employed other skilled workers than carpenters) had lower survival rates than “typical firms”. However, almost no firms with mixed professional background (i.e. specialised firms) could be identified, which on the one hand does not allow for additional empirical testing, but on the other hand can be interpreted exactly as a sign of the benefits of “being alike” in construction.

relations between specific persons or firms (see the previous section) could potentially account for this.

Consequently, the study does not contradict the theoretical claim forwarded in chapter 2, that changes in demand (i.e. the macro level) transform into changes in working constellations between projects, which go on to promote changes in the relation between the activities within the single project, which eventually creates a lower level of repetition in the single activity. Accordingly, a limited level of specialisation within (or between) firms is likely to go together with a limited division of labour at the level of individuals (as the division of labour is dependent on repetitive activities).

Thus, a potential drawback from isomorphism is a lower level of dexterity within a particular field. Or, as seen in construction, that more resources have to be devoted to the development of widely applicable skills (“craft production”). Furthermore, presumably the limited division of labour results in a lower rate of invention of machinery to replace manual labour (an indication of the latter would be a relatively low capital-to-labour fraction in industries with low levels of repetition).

Taking these drawbacks into account I *do not* suggest that isomorphism always is superior to specialisation. As captured in proposition A, the benefits of isomorphism appear to most dominant when adaptability to new working constellations are of essence due to some kind of external changes, and hence, it is expected only to be dominant with low levels of repetition in sequences of activities.

7.3 Proposition B - Perspectives on the firm as a coordinator

7.3.1 The limited role of the firm as a coordinator

The theoretical part dealt with the trade off between benefits of repeating sequences of activities with benefits of being able to adapt to changes in external conditions. It was argued that in order to reap the fruits of specialisation, an unstable environment promotes not only persons specialised in performing specific activities, but also persons specialised in *coordinating* these activities. The job of coordination specialists is to adapt to external changes and, if necessary, to restructure activities internally in the sequence of repeated activities (and thus, two different

kinds of coordination specialists may occur). It was further argued that through authority and ownership, the specialists in coordination could reduce the costs of transferring *decisive* information, and the costs of *experimenting* with (re)structuring activities. And hence, that the firm perceived as a set of repeated interactions between activities, would not differ largely from the contractual or legal boundaries of the firm. Put differently, the incentive based view and the information based view on the firm respectively, do not seem to differ much with respect to where they draw the boundaries of firms.

The empirical observations support this. Activities interacting repeatedly, are lastingly under the same direction and are performed by using tools and equipment belonging to the same owner(s). And equally, unified authority and ownership on a more than temporary basis, is only found for activities that are fixed together repeatedly. Many different firms are involved in roof production whereas, each firm covers a much wider span of activities in furniture production (presumably working under more stable external conditions).

However, or perhaps because of this, the empirical findings also demonstrate that firms do not always experiment with, or provide information structures for, a sequence of repeated activities. To put it more precisely: when sequences of activities are not repeated, (some) firms play a much more limited role concerning coordination, as they only coordinate *between*, but not *within*, value chains. The coordination practices found in the construction and sofa-producing firms, respectively, illustrate this point.

In sofa production, a string of subsequent activities is carried out within the firm. When a new product is launched, the management of the firm experiments with and determines the activities involved in producing this new product. Broadly speaking, this appears to be in line with the interpretation of K. Foss. Yet, there are some small nuances to the story on experimentation. Experimentation in sofa production is about finding out how a new product can be defined in such a way, that it becomes possible to handle with a given set of activities, i.e. by using existing tools, dies and working procedures. And as part of this, selecting the

exact activities, as well as the sequence to use for this particular product.⁴ It is less about developing new tools, dies, and working procedures as K. Foss pointed out as important elements of firm-based experimentation.

And similarly, as a modification to Casson's reflections on decisive information, it is found that both specialists to external changes (i.e. people working in the purchasing and sales department) and specialists in internal coordination (the shopfloor managers) are involved in the process of designing new sofas. Hence, the sofa production does not appear to be either design or market led and accordingly, none of these two groups of specialists are expected to hold decisive information. This seems somewhat surprising, considering that external conditions vary quite a lot due to changes in the preferences of customers, whereas the employed technology does not appear to be very capital intensive or subject to frequent changes. According to Casson (1994), this suggests high decisiveness in demand and low decisiveness in technology (favouring a market led firm). An alternative explanation of the empirical findings, similar to that offered as a refinement to K. Foss' contribution on the importance of experimentation, is that decisiveness in technology is high due to advantages of specialisation and low coordination costs following from well-known interactions between activities. The shop floor managers are not included in the decisions on future products because technology changes, they are included because technology *should not change*.

Nevertheless, in the overall picture, the sofa-producing firm seems to correspond well to picture of a firm as a trinity specialised in (I)

⁴ Consequently, the sofa firm is able to produce a variety of different products using the same pool of activities. What is needed in order for decisions to be repetitive enough to make the creation of the firm economically viable, is not a steady stream of demand for identical products: the sofa firm can produce a few sofas of type A, then some of type D, switching to type B etc. and still maintain a high level of repetitiveness in activities. The only thing that really changes at the factory floor is the sequence of activities (defined once and for all by the management) and occasionally the dies. However, over time and on average, a particular sofa of, say, type A, should be expected to be called for repetitively in order to pay for the initial costs invested in locating and implementing the appropriate sequence of activities for this particular product. In short, what matters for creating the firm as a coordinator *lengthwise the value chain*, is not repetition in the sense that product A follows product A, but that within a given time frame product A is requested a minimum number of times, and that the sum of different products ensures a steady level of production.

coordination of external changes (performed by the purchasing and sales department), (II) coordination of internal changes (performed by shop floor managers), and (III) production of activities (performed by the workers). However, this conceptualisation of the firm is not very apt for construction. The degree to which construction firms (i.e. subcontractors) engage themselves in length-wise coordination is hardly worth mentioning, as it is in the hand of project management and design consultants; i.e. is taken care of by external firms. Hence, construction firms as such do not experiment with how to delegate user rights in order to decompose a string of activities in the most favourable way. Nor do they to any significant degree establish a product particular structure to facilitate information transfer between the group of people involved in production. Partly, these functions are in the hands of firms specialised in coordination, i.e. the firms of the design team, and the firms responsible for project management. Partly, and perhaps predominantly, the role of experimentation and information structuring is minimised and taken care of, respectively, by the trade-organisation of the sector. Consequently, the need to organise construction according to common and well-known patterns, implies that some of the functions of the sofa production firm are moved to firms specialised in coordination, if not beyond the realm of any single firm (i.e. to the sectoral level).

But what then is the role of the construction firm? Rather than coordinating *within value* chains, they coordinate solely *between* value chains. By moving equipment and in particular personnel from one construction site to another or from one part of the construction project to another, construction firms try to optimise the use of production facilities (identical to what sofa-producing firms do, when they shift back and forth between different types of sofas). Here, only specialists in coordination of external changes are found.

The *raison d'être* for this type of construction firm appears to be more related to Coase's general notion of the firm as a way of allowing ongoing adaptation to situations that are difficult to foresee, than to the specific experimentation-interpretation (or any other interpretation assuming that subsequent activities are placed within the firm) given by K. Foss (2001b).

In short, the firm can act as coordinator in two different set-ups. (A) Some firms handle market fluctuations and disrupts in production by coordinating activities between value chains and along the value chain, respectively. Experimentation and structuring of information is an important part of the latter. (B) Other firms play a much more limited role with respect to coordination, as they only coordinate between value chains, leaving coordination along the value chain to *third party coordinators*, or to general norms and rules that apply to the sector. Theoretically, it has been argued, and for roof and furniture production it has been found, that when external changes are high and cannot be resolved by shifts in markets, firms of type B will dominate, whereas firms of type A are more prevalent in stable settings.

The different ways in which coordination is organised in sofa and roof production are summarised in figures 1 and 2.

Figure 1: The organisation of coordination in sofa production (repetitive production)

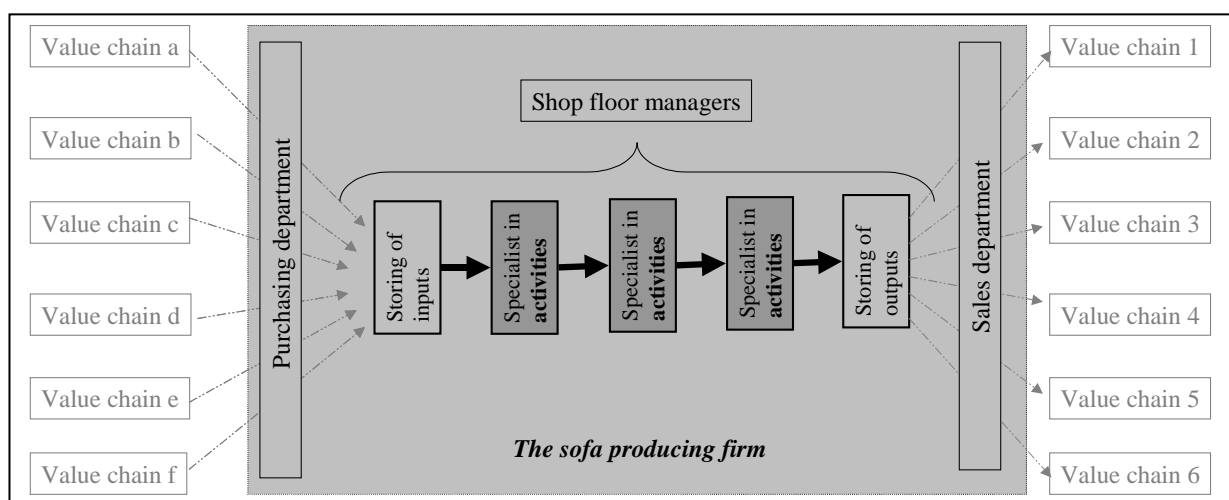
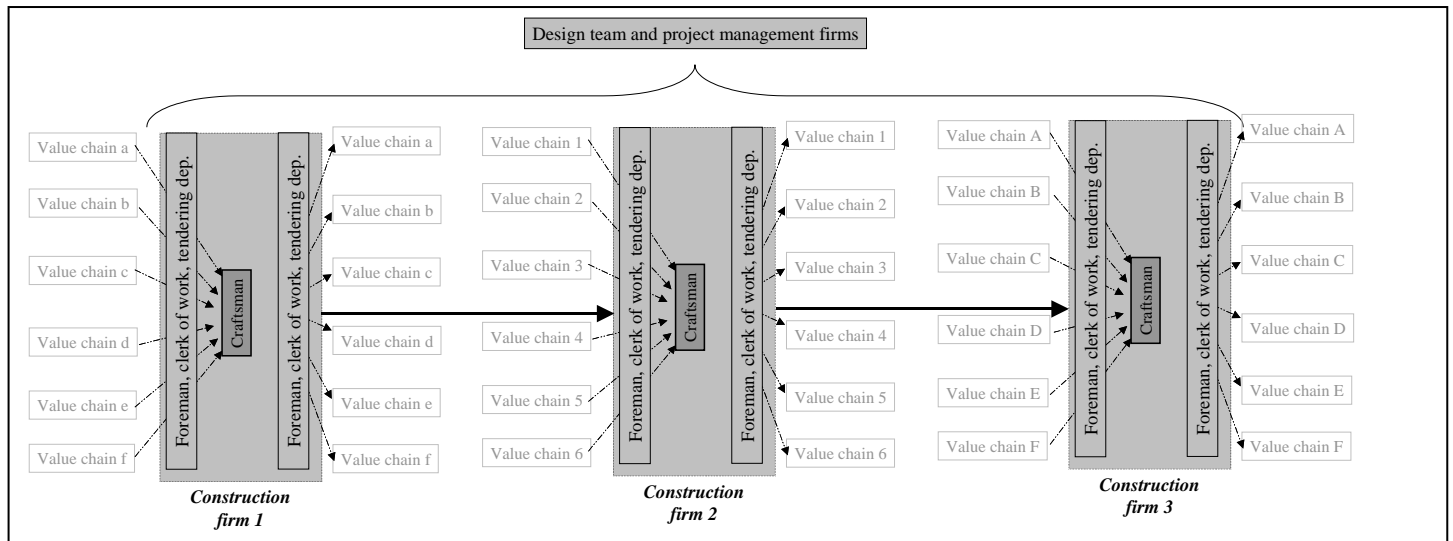


Figure 2: The organisation of coordination in roof production (non-repetitive production)



The organisation of coordination in sofa production appears to fit well with the stylised picture given of the firm as a coordinator in chapter 2 (Figure 1, section 2.3.). A sequence of identical activities is recurrently performed within the firm by the specialists in activities, i.e. by the workers (for a more exact representation of these activities, see the figure on activities in sofa production in chapter 6). Coordination of these activities is taken care of by the instructions and, in particular, the procedures and dies outlined by the shop floor manager who have specialised in internal coordination. External fluctuations are buffered not only by storing, but also by the purchasing and sales department, who – despite the long-term cooperation with some suppliers and costumers - shift back and forth between different markets for input and output respectively.

In construction, however, the picture is very different. A construction firm only occasionally performs a repeated sequence of activities. Rather, construction firm 1 performs a single activity, then construction firm 2 completes the next (sub)part of the building, and so on (at a certain point construction firm 1 will once again enter the value chain momentarily). Each construction firm buffers quantitative fluctuations by working on multiple parts of the building and on multiple building projects. Thus, not only is repetition limited in the sense that the persons do not interact over time (as part of producing identical products repeatedly); even

within a very short time span the attention of craftsmen can be dispersed among multiple projects. Within the project, the foreman switches around which parts of the building to work on. The clerk of work allocates manpower between building projects, and the department of tendering ensures a sufficiently large, but not too large, pool of ongoing projects. Coordination within the single building project is not coordinated within the construction firms, but are placed in the hands of external firms; i.e. third party coordination by the firm of architects and the firm of engineers (the design team) primarily executing their work during the idea and planning phase, and by the project management firm (that on some occasions is identical to one of the construction firms), that primarily works during the phase of execution. As the interaction between construction firms usually is on a one-off basis, so is the relation between the construction firms and the third party coordination firms (as well as within the third party coordinating firms).

7.3.2 Third party coordination

This raises the question of how coordination of subsequent activities is organised when these activities are not placed within the firm. Who takes over the responsibility of coordination in the presence of type B firms (i.e. firms that only coordinates between – not within – value chains)?

The role of third party coordination - some problems with market based and bilateral interfirm coordination

In order to answer this question, let us consider the organisation of construction, where the (sub-)contracting companies usually are of type B.

Ideally, the process of construction could be organised in such a way that firms buy the input from the previous trade, and after executing a number of activities resell it to the next firm in line. However, the need for adaptability disfavours the internalisation of long sequences of activities in the firm, as well as the organisation by long term interfirm coordination (“cooperation” in the terminology of Richardson (1972)). Thus, the number of firms involved (even in parts of) house construction is substantial, and their interaction is not facilitated by repeated interaction. Consequently, the cost of forming contracts between the

numerous firms (that is, more a less a contract for each activity) would be enormous. In addition, as the output at any given point of the value chain is not identical from one project to another (the intermediate products are not *standardised*), the input is not buffered by the principles of large numbers or by cheap storage (i.e. they are not easily handled by a spot market). Secondly, low levels of standardisation of products imply that contracts are more easily formed after, than before successful completion of previous activities. In a buy-and-resell system, this would most likely delay the building process and thus impose additional capital costs.

The assumed costliness of organising interactions by such market based buy-and-resell systems, seems to fit well with the observation, that a subcontracting system is widespread in Denmark. In this subcontracting system, the subcontractor provides manpower and usually also additional materials, but the subcontractor does not own a part of the building at any time. Furthermore, contractual costs are reduced by bunching activities together (e.g. all the carpentry work on a building site is usually done by one or a few carpentry firms).

When the objects subject to transformation are not owned by the subcontractor, the “burden of proof” concerning the value added to the product by him or previous subcontractors, is likely to change. As the subcontractor cannot be harmed by a low reselling price, in the outset he has no compelling reasons to convince or prove to a buyer, that the quality of his work is acceptable. Rather, it is the job of the general contractor to prove, that the subcontracted work *has not* been done in an acceptable way (i.e. the way it is outlined in the initial contract).

In a situation of symmetric information, this would be of little importance. But if asymmetric information exists – e.g. the general contractor does not have and cannot cheaply acquire the same amount of information as the subcontractor on, for instance, the quality of the work performed by the subcontractor – the situation is different.⁵ Here, the

⁵ The problem of asymmetric information in construction is supposedly high for at least three different reasons. Firstly, many parts of the final (and even intermediate stages of the) building are not visible to the client or to project management, as subsequently added parts physically cover them. Secondly, due to the long lifespan of a building, many errors are revealed long after construction which reduce the danger of being held responsible if an information advantage is (mis)used. And

subcontractor is more likely to use his information advantage to lower the quality of his work, since the general contractor, and not the subcontractor, carries the burden of undocumented quality of work.

Another implication of the subcontracting system is, that, since subcontracting firms do not own the objects they are working on, they are not burdened by the (rather huge) capital costs created by, say, an unfinished building. The client (who owns the building) carries these costs. Strictly speaking, the interest of the subcontractor is to build in a pace, where he optimises his production capacity, i.e. allocating as few persons to the site as possible.⁶ The interest of the client is to reduce building time and hence capital costs, i.e. having as many persons as possible allocated to the site.

In light of this, the reasons for the continuous presence of a *project management* firm working on the building site appear to be twofold.

Firstly - in order to compensate for asymmetric information - to assess the quality of the work performed by subcontractors.⁷ Secondly, in order to look after his interest, the client needs to set up timetables, as well as sanctions, e.g. fines for delays, if these are not followed. As the execution of such sanctions requires information about local conditions - e.g. is the delay caused by external phenomena, such as the weather, or by a calculative subcontractor (and which one) - the more detailed planning, as well as its reinforcement, is well placed with a client representative working on site, i.e. the project management.

even if they are recognised by the client at the time the building is handed over, it can be very difficult to point out exactly which firm to blame, due to the many different firms involved. Thirdly, the benefits of (mis)using asymmetric information have to be traded off with the risk, that the counterpart most likely would act in a less collaborative way in subsequent meetings. However, this mechanism is weak in a sector, where collaboration (for reasons given above) is not expected to exceed the length of the single building project.

⁶ By having only a few persons allocated to the site, the subcontractor does not risk to have idle production facilities. The only risk is to be delayed, a problem the subcontractor for the reasons given has no economic reasons to be concerned about (unless, of course, countermeasures such as fines for delays are taken).

⁷ The existence of the quality insurance system- in which the subcontractor is obliged to document the way he has progressed with his work - used in the Danish construction industry, can be interpreted as another measure taken against scamped work.

Third party coordination in the production phase

These reflections and propositions give ground to expect that particular incentive-problems arise when many and subcontracting firms are temporarily involved in production. This in turn favours the existences of one or more third party firms engaged in monitoring and enforcing on the work of subcontractors.

Adding to these incentive based explanations for the existence of third party firms, are considerations regarding how to minimise on communication costs. In short, it can be costly for constructing firms to communicate directly with each other simply due to the many and temporarily involved firms. First of all, as the number of companies expands, other things being equal the need for a more centralised network design is accentuated. And secondly, it is not always feasible to identify which person to talk to. As a firm carrying out many activities at the same time, they can be allocated all over the site. Or perhaps they are not at the site for the time being. If the same persons were working together on a more permanent basis, direct communication lines could be established, but as new firms and new persons are selected on a project basis, personal relations have to be rebuilt recurrently.

In this way, the project management acts as a centralised communication node enabling communication between subcontractors, as well as communication between subcontractors and people working off the site (e.g. project management). Due to the short span of activities carried out by the single construction firm, the degree to which these overarching communication structures can be placed within the legal boundaries of each of the subcontracting firms is very limited. Thus, unlike in sofa production, third party firms specialised in transferring information between distant parts of production arise.

In combination, this gives reason to conjecture the following: the less repetitive sequences of activities are, the less frequent is coordination in the *production phase* performed by unilateral coordination within a firm or by bilateral coordination directly between two firms, and the more frequently is coordination performed by a third party firm. Important elements in the work of a third party during production (i.e. *the project management* in construction) can be to (a) monitor the quality of the ongoing work of subcontractor; (b) to enforce timetables on behalf of the

owner of the product; and (c) to act as a communication node between the subcontracting firms.

Third party coordination in the design phase

Up to now, the role of project management in construction has been discussed, i.e. the use of a third party during *production*. But as witnessed in the case study on construction, the team of architect, engineer and main contractor also plays a critical role in the coordination of building activities in the design phase. Except for the general contractor occasionally, the persons involved in the design team are employed in firms that do not engage in contract work directly on the building site, and usually do not repeat their interactions with other firms from the design team or with subcontracting firms. Thus, like project management, the members of the design team represent third party coordination in both the legal sense of the firm, as well as in the perception of the firm as a set of activities and resources. However, unlike project management, the majority of the work in the design team is done prior to (i.e. in the planning phase) and not during construction (i.e. the execution phase). Correspondingly, the design team serves other purposes than the project management with respect to coordination.

One part of the work of the design team is to *centralise information processing* and thus *avoid duplication*.

For instance, it is the responsibility of the design team to design the building according to the budget and needs specified by the client. This work starts with making the very first sketches and overall dispositions in dialogue with the client and ends with the very detailed drawings specifying the materials and layout of each part of the building. Usually, the client expresses his demands in general (and not technical) terms related to the final result (and usually not related solely to the work of any single trade). Hence, the design team can be understood as a way to avoid duplication, by centralising the information processing involved in transforming the overall demands of the client into technical formulated specifications and thus, reduce information costs.

Calculating the static of a building is another example of gains from centralising information processing relating to multiple parts of a building (and hence to the operation of multiple firms). In order to

calculate the static of a building, the interaction of all vertical and horizontal forces has to be considered. It does not make sense to calculate the static for a very delimited part of the building on its own. And consequently, if a subcontractor is to do the static, he has to consider the work done by the other subcontractors and likewise for each of the other subcontractors. Hence, by placing this job in the hand of a single firm, overlap of work can be avoided. This and the previous example illustrate Casson's claim (1994), that sometimes it is easier to transmit decisions than the conditions on which they are based.

Centralised information processing on, for instance, taste of customers was also found in sofa production. Here, it was the responsibility of the sales department to follow market trends and then – as a member of the team involved during production of the first two or three batches of sofas – transform them into technical specifications. In sofa production, these centralised and specialised information processing (and transmitting) units are kept in-house, except on very rare occasions.⁸ However, due to numerous firms involved in construction, to place this function within each of the subcontracting firm will result in a lot of overlapping work. Hence, the shorter the string of activities internalised within a firm, in order to avoid duplication, the less coordination will be done by the producing firm itself and the more coordination will be done by a third party firm.

A second objective of the design team is to *avoid sub-optimal* solutions. The existence of multiple separate firms is also likely to create incentive problems if solutions of design and pace of completion was placed within each of the subcontracting firms. For instance, when the carpenters commence the construction of the roof, they could choose a solution that is fully consistent with the specifications of the client, but at the same time a solution that is very difficult for say, the ventilation plant people, to proceed with (for instance due to low accessibility). The “lack” of repeated interactions between specific persons and firms probably accentuates this problem. By placing the specification and rate

⁸ One of the two furniture firms reported that they “once and many years ago” had used an external architect in order to design a new sofa. Apart from this example, the design people (usually a skilled upholsterer but not a furniture designer) had always been employed in-house.

of completion of technical solutions in the hand of a party that it not itself engaged in production, the risk of such sub-optimising behaviour is reduced.

Finally, as also discussed in the previous section, one potential benefit from third party coordination in the planning and in the production phase is that it enables communication (*ex ante* or during production, respectively) between activities that are temporarily separated or are placed in distant parts of the value chain. A phenomenon we may call “horizontal skip level reporting”.⁹ As seen in the case studies on sofa and roof construction, decisions taken up-stream the value chain can have implications for neighbouring activities *and* for activities several steps down the value chain. The more distant interrelated activities are, assumedly the more costly it is to transfer information horizontally back and forth the value chain (among other things, there are costs related to duplication in *transfer* of information, as well as noise-costs due the multiple persons that the information runs through). Apparently, if unintended externalities are to be avoided, this situation encourages distant levels of production to interact directly. However, the knowledge of by whom non-neighbouring activities are performed may be limited and perhaps – as seen in construction – the persons performing non-neighbouring activities may not be present at the production facility at the same time. So, even though the introduction a central agent implies an additional communication link compared with direct communication (but not compared with horizontal communication through all stages of production), it may reduce communication costs between non-neighbouring activities.

As for the organisation of coordination during production, I conjecture that the less repetitive sequences of activities are, the less frequently coordination in the *planning phase* is done by unilateral coordination

⁹ The term “horizontal skip level reporting” refers to Balton and Dewatripont’s (1994) discussion of (vertical) skip level reporting, that is reporting given by a subordinate not to the immediate superior, but to superiors two or more layers beyond the subordinate. Balton and Dewatripont argument is that the extent of (vertical) skip level reporting is limited in an efficient communication network. As I argue here, this conclusion is not necessarily valid for horizontal skip level reporting, that is reporting given between non-neighbouring activities possibly mediated by a superior level (in which case it includes vertical elements as well).

within a firm or by bilateral coordination directly between two firms, and the more frequent is coordinating done by a third party firm. Important elements in the work of a third party in the planning phase are: (a) to avoid duplication of information processing; (b) to prevent technical solutions that are favourable to a few, but harmful to many firms; and (c) to bridge communication between distant parts of the value chain (horizontal skip level reporting).

7.3.3 Limits to third party coordination

To sum up, in situations with little repetition in sequences of activities, there appears to be many advantages from placing the execution of activities and the coordination of activities in separate firms. However, the case study also points to disadvantages of not repeating interactions between the parties coordinating and executing activities, respectively.

First, decoupling coordination and execution of production limits *hands-on experience* as an important source of *innovation*. The case study on roofing gave several examples of how the craftsmen identified ways to improve the product or the working process. However, according to the craftsmen these observations were rarely utilised. One part of their explanation related to the long communication lines: a suggestion is forwarded to the project management, who forwards it to the design team, who considers the idea and reports back to the subcontractor via the project management. The subcontractors found this long response time to be very discouraging. However, the craftsmen also felt that the design team had difficulties in understanding what the problems were all about. A possible interpretation is that low levels of repetition in communication – in particular in combination with a design team working off the site¹⁰ – increase the cost of communication.

Hence, an expected drawback from placing activities and coordination of activities in separate firms is that the information costs of using hands-on

¹⁰ The obvious question then seems to be why the work of the design team is not done *on* the site. The immediate answer is that this would be difficult, because members of the design team usually work on multiple projects simultaneously (which also limits the co-location of the design team off the site). Thus, the explanation points towards that specialisation also occurs *within* the design team, which makes it difficult for any single person to be fulltime employed on a single project unless it is of a certain size.

experience as a source to innovation is increased. With respect to possible empirical indications, this claim infers that the more coordination is done by third parties, the less innovations are made in working procedures and tools used by the workers, but due to higher level of specialisation, the more innovations are made in the procedures and tools used by the coordinators.

The case study on roof construction also illustrates how trilateral coordination raises *incentive problems in balancing production and coordination costs*. The design team exerts coordination along the value chain, but is not directly affected by the state of coordination. Hence, they have a tendency to under-invest in coordination. As one person from the design team said during a meeting in the planning phase: “I do not spend an extra working hour just to reduce building costs with 5000 DKK [approx. 600 ECU]”. It is hardly likely that 5000 DKK exceeds his costs of a working hour (including overhead). Similarly, as subcontractors are paid for doing a particular job, and not for a final house, their main focus is on reducing production costs and not on striking the balance between production AND coordination costs. As observed with respect to the roof houses, the subcontractors occasionally performed an activity as described by the design team, knowing that it would create significant problems for other subcontractors. But as they acted according to the contract – and perhaps even had a chance to earn extra payment for reworking their own output – they did not always inform the design team or project management about this.

Thus, under-investment in coordination prior to production and lacking attention to coordination during production is a likely outcome of separating coordination from production. Of course there are limits to the under-investment in coordination. Firstly, even though contracts are not complete, they do specify some minimum requirements. Secondly, and perhaps more importantly, although they are not paid directly according to the quality of the final product, all parties are to some degree dependent on a good reputation. And hence, they do not wish the project to be a total blunder. Furthermore, even though it is for a limited period, there is some level of mutual dependence between the design team and subcontractors, as well as directly between subcontractors (Kreiner 1976). This encourages the design team to

improve the coordination effort, and favours that subcontractors do not focus too narrowly on their own work.

In conclusion, these disadvantages give reason to believe, that coordination by a third party is less widespread in environments with higher level of repetition in sequences of activities than, for instance, found in construction. Perhaps, they can also be part of an explanation for why – in spite of the fact that the general benefits of specialisation also apply to coordination – production and coordination of production is often co-located within the firm.

7.4 Proposition C: Perspectives on coordination modes

Adam Smith highlighted repetition of *activities* as the source of the division of labour and thus, as a source of “wealth of nations”. The smithian argument essentially is that repetition lowers *production costs*. Yet, as claimed in proposition C, repetition may also promote growth by other means, since repetition of *sequences of activities* can lower *coordination costs* (which again can allow for a greater division of labour and thus, lower production costs).

The empirical study has highlighted three mechanisms of reducing coordination costs not very different from the three production costs mechanisms identified by Smith (lower switching costs, “dexterity”, and innovation). Repeated sequences of activities lower the costs of identifying appropriate coordination modes, that is *switching costs* induced by going from a well-known to a less well-known sequence of activities. Secondly, repetition of activities lower the costs of using a given coordination mode, as the persons involved become more knowledgeable and experienced in using it (they increase their *dexterity*). And finally, due to repetition it becomes possible to define, or *innovate*, activities in such a way, that they are easily coordinated.

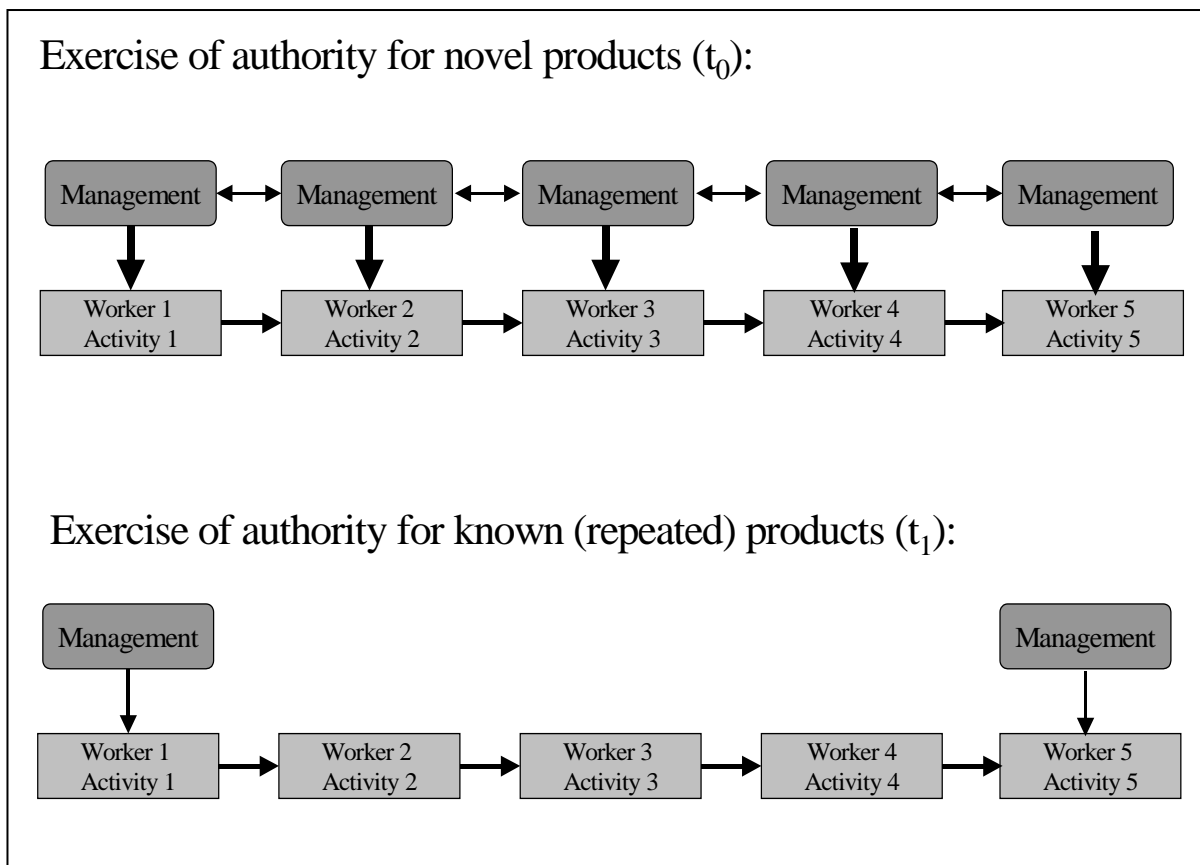
This subsection is organised according to these three different mechanisms. As in the previous sections, the stylised facts of the roof and sofa case leading to, or following from, the more general proposition C are presented and discussed.

7.4.1 Lower coordination costs due to dexterity

How coordination by authority changes over time

The empirical observations from the furniture and construction industry suggest, that the level of repetition matters for the exertion of authority. Not so much with respect to whether it exists or not, but more with respect to what different forms it may take. In order to see this, consider figure 3 which sketches the role of authority at time t_0 (denotes when a product is made for the first time) and t_1 (denotes the role of authority when a product has been produced repeatedly). The role of authority in t_0 represents the sofa as well as the roof case, whereas t_1 (due to lack of repetition in construction) only illustrates the role of authority in sofa production.

Figure 3: Repetition and the exercise of authority



In t_0 management in both sofa and roof construction plays a rather direct role throughout all stages of production. Mainly by direct communication, management informs the workers on how to perform each activity. In roof production these instructions concern in particular the outcome of the activity, whereas instructions in sofa production also include a very thorough description (often formulated in manuals) of the working procedures for the different tasks involved in each activity. Later (t_1), when these procedures are laid down (and often have become routinised), the management of sofa production plays a much more limited role, as it is mainly concerned with getting the production of a sofa started (i.e. to inform the first person in the production line that this and this sofa should be produced now) and checking towards the end of the production line that sofas are ready as ordered. Often this function can be done directly by the sales department, but in case of an urgent

order, shop-floor managers can switch around batches at selected stages of production.

So even though authority is present in both the roof and the sofa case, it will look very different in each case. In construction, authority is mainly done by the giving and taking of orders directly between superior and employees respectively. In sofa production, authority is harder to see in most phases of production, as it is inherent in the working procedures, tools and dies once and for all established by management. In the terminology of Arrow (1974), authority in construction is mainly *personal*, whereas it is *impersonal* in sofa production.

More generally, this implies that the more sequences of activities are repeated, the more authority will change from being exerted directly by management in all stages of production, to being exerted indirectly in selected stages of production.

The dissimilarity in the use of authority in roof and sofa production respectively illustrates another point: the various carriers of information. In construction, information is mostly provided by verbal or written communication. In the case of sofa production, people appear to communicate less, but how then is information transferred from one part of the value chain to another? Part of the answer lies in the extensive use of routines, which have captured the lessons from previous interaction and thereby rendered further communication unnecessary. However, this is not the whole explanation. *Information embedded in dies and flows of materials* is also found to be very important in the case of furniture production. Dies replace instructions about what to do and how to do it. Similarly, by fixing a person to a given workstation, and by forwarding the exact amount of materials needed, instructions on when to perform an activity and how much to produce can be reduced, as they are inherent in the flow of products. Only if deviations from this general pattern are necessary, managers have to intervene and instruct workers. In this way the established flow of materials running through thoroughly described work stations functions as what Casson and Wadeson (1994) termed a *protocol*; i.e. a procedure that economises on communication costs by clarifying exactly how much information to forward, what the information should be about and the way it should be sequenced.

In situations with low repetitiveness, these carriers of impersonal communication are costly to use (there are set-up costs of making dies; fixing a person to a particular workstation requires a stable production; to forward the exact amount of materials for the next operation requires experience about, among other things the exact waste rate). However, when production is repeated, these costs are outweighed by the lower variable information costs.

Another more general implication of a high level of repetition in sequences of activities thus appears to be, that the information embedded in tools and dies and in materials flowing horizontally along the value chain increases, whereas vertical communication between superiors and subordinates decreases.

Change in authority over time – implications for hierarchical layers and the size of firms

Thus, part of the benefits of repetition has to do with the replacement of expensive information carriers with cheap ones. An important implication of this (and, in general, of ad II in proposition C) is that managerial resources are gradually freed due to repetition. As seen in furniture production, management was very engaged in production during the design and production of the two or three first batches of a new kind of sofa, but after this, there was minimal interference in production. For the same reason, each superior is able to instruct a large number of subordinates. For instance, in the largest of the two sofa producers on which the case study was conducted, three shop-floor managers instructed and supervised 120 employees. In the case study of roof construction, it was found that there usually is a superior person (i.e. a foreman or clerk of work) for each 5 to 10 employees. This latter observation seems to be consistent with the fact that the size of a construction firm rarely exceeds 10 persons.

Since repetition increases the number of subordinates related to a single superior, it could be expected that repetition also reduce the number of hierarchical layers in an organisation. Even though the case studies did not aim at exploring the issue of hierarchical layers, the empirical findings do not appear to contradict this line of reasoning. In the case of repeated production (sofas), three main hierarchical layers appeared:

worker, shop-floor managers and management. In the case of less repeated production (roofing), six hierarchical layers were identified: craftsmen, foreman, clerk of work / master, project management, the design team and eventually the client. No exact measures on the overall number of people working directly on the construction project have been made, but a rough estimate would suggest, that the number did not exceed the number of people employed in the larger of the two studied furniture producers (approx. 120 employees).

In combination, these three propositions suggest that it may be difficult to estimate whether the level of authority is higher in, say, construction than in manufacturing (as fiercely discussed by Stinchcombe (1959) and Eccles (1981b)). In the one hand, authority is more dominating in construction, because managers are present and give instructions throughout the entire process of production. The presence of many hierarchical layers may also promote a picture of construction as being very much determined by centralised decisions. On the other hand, authority is less dominating in construction compared with sofa production; as working procedures, tools, and dies are not totally defined by management or inflowing materials, some decisions are left to the craftsmen.

As observed in sofa production, when managerial resources are freed, management has time at their disposal to test new ideas and products. Some of these ideas do not work out well, whereas others eventually become a success and the firm expands its activities. Thus, the case study on sofa production supports the Penrosian idea, that hitherto unused managerial resources are an important source to why firms expand their size. And hence, it would be expected that growth in size of firms is different in a repetitive situation than in a non-repetitive one, as more managerial resourced are freed in the former. Perhaps this line of reasoning, at least partially, can account for the very small growth in the size of construction firms observed in chapter 5.

The persistence of authority in temporary and innovative organisations

Pertaining to this discussion of authority, the conclusion is that even though authority to some respect is exerted differently in a temporary than in a stable setting, it exists in both cases.

Thus, construction can inform us of the organisation of sectors in which firm-based authority supposedly plays a limited role. The idea is – in consistence with much of the recent debate on how to organise in innovative and learning environments (N. Foss 2000a) – that in situations of great novelty (lack of repetition), it is not only difficult, but also unsuitable to put up defined goals in entering a process of innovation, where goals by definition are unknown. At the same time it is as difficult for managers to monitor or routinize activities that do not follow a recurring and well-known pattern, as it is to absorb the new knowledge being created. Hence, the argument goes, the more innovation and learning become of essence, the more centralised decision-making fades in favour of local decisions made by employees, or groups of employees, who are aware of, and can promptly react to, new and unforeseen situations.

Now, let us take stock of the empirical results in order to see, if and how the use of authority is different in environments with temporary organisations and rather high levels of novelty (as in construction), than in more stable environments (as in sofa production).

First of all, it appears that the claim, that lack of repetition favours some delegation of decision rights to local levels, holds some validity. Elements of *craft production* were found in construction, where craftsmen to a higher degree than employees in furniture production decide themselves, which tools and working procedures to use. However, even in construction a wide range of issues on the craftsmen-level was settled by central decisions made either internally in the construction firm (i.e. questions on when and by whom activities should be done), or externally by the design team (which materials to use, how much to produce and the finish of the output).

As it appeared in the case study on construction, lack of repetition did not only make decisions by authority more costly. To some degree, it also made it more difficult to handle information by local decisions of the employees. First, due to the novelty, it is very costly, if not impossible, to design activities with little interdependence. And consequently, local decisions by a single agent would often create sub-optimal solutions. This in turn calls for teaming, that is local decisions by the group of people performing the highly interdependent activities. But

again, due to the novelty, it is not easy to say exactly which activities that are highly interdependent on this particular project (recall the example of the roof houses discussed in chapter 5). And hence, the team easily grows beyond a size, which works with reasonable costs of communication. Further, the temporary and only partially simultaneous presence of the different construction firms is also a potential barrier to the use of teaming.

Thus, on the one hand it was found that novelty (lack of repetition in sequences of activities) increases the costs of centralised decision-making by authority, but on the other hand also increased the costs of local decision-making by a single employee or by groups of employees. Consequently, the net effect of novelty / temporal organisations on the level of centralised decisions by management versus decentralised decision by employees appears to be less dramatic than often claimed (N. Foss 2000a).

7.4.2 Lower switching costs to identification of coordination modes

The empirical findings suggest a revision of the relation between activities and coordination modes outlined in the theoretical part. The first clarification relates to the learning cost of identifying coordination modes when switching to new sequences of activities with unknown interdependencies; costs that *weaken the causality* between the informational properties of activities and coordination modes. As the authors presented in chapter 3 did not pay much attention to this type of costs, such a gap between expected and actual coordination modes could not be accounted for. The second revision (discussed in the next section) suggests a *revised causality* between activities and coordination, and in particular argues for the contingency approach.

A common feature of the theoretical contributions presented in chapter 3 is that coordination modes are expected to correspond to the interdependence of activities and the informational properties following from these. However, we do not observe such a clear-cut relation in the case studies. The information involved in coordinating activities varies to a large extent in construction, without subsequent changes in the applied coordination modes. As illustrated, some of these “lacking” adjustments are difficult to account for, unless the cost of identifying the appropriate coordination mode is included in the analysis. These costs may be

negligible in a repetitive setting, but in construction, where the exactly same sequence of activities is rarely made more than once, they are of significance.

Consequently, the selection of coordination practices must be expected to be different in temporary organisations compared with more permanent ones. The more sequences of activities are repeated, the lower the costs of identifying appropriate coordination modes become and thus, the more coordination practises will vary according to informational content of the activities subject to coordination. Accordingly, the gap between the theoretically expected (according to chapter 3) and the actual coordination practices can be expected to be particularly high in temporary organisations.

7.4.3 Lower costs of innovation of “easy-to-coordinate-activities” - revising the causality between interdependencies and coordination modes

One might expect, that in the case of sofa production, the lower cost of identifying appropriate coordination modes would result in more varying coordination modes, as they are fine-tuned to the exact interdependencies between each set of activities. However, this is not the case; rather, repetition is used to break up the value chain in activities for which working procedures can be standardised and in turn routinised; a process that reduces coordination, as well as production costs. And thus, as for construction, a rather uniform (although different) set of coordination mechanisms is used for a wide range of activities.

Hence, in sofa production, coordination modes are not adjusted to given interdependencies. On the contrary, activities and their interdependencies are defined in a way that corresponds to a particular coordination mode. This observation disagrees with the contingency views and favours the more recent approach offered by, for instance, Hippel (1990) and Grandori (2000), that causality between activities and coordination are a two-way , and not one-way – relation.

In general, two different strategies can be pursued to fit coordination modes and activities: (a) change coordination mode and / or (b) change activities (and thus, the way they are interdependent). The empirical observations from construction and furniture production, respectively,

suggest that the former strategy is mainly used in a non-repetitive situation; and the latter is used when repetitive interactions between activities occur. Although the empirical foundation is limited, and a theoretical argument to why fixed costs are lower and variable costs are higher for strategy (a) than (b) is missing, this suggests that with low degrees of repetition in activities (a) is dominating, whereas strategy (b) is dominating with high degrees of repetition.

Where the discussion in section 7.4.1 emphasised how coordination costs are lowered by repetition due to the *subjects of coordination* (i.e. due to the increased skills of the persons involved in coordinating activities), this discussion illustrates how coordination costs are lowered by repetition due to changes in the *object of coordination* (i.e. less complicated interdependencies between activities).

In the case of sofa production, activities were designed in a way so that they could all be handled by standardisation (and in turn routinisation). Besides being a costs effective way of coordinating repetitive interactions due to low costs of processing and communication of information, the use of a single coordination mode is likely to hold many advantages, for instance lower switching costs and increased skills. This line of reasoning does not say anything about which particular coordination mode comes into play due to repetition. Yet, it shares Thompson's idea, that a single coordination mode is used for activities that are simple to coordinate, whereas more complicated issues call for multiple coordination modes.

7.5 Some implications for the study of coordination modes

Interdependencies and coordination modes

In summation, the discussion on how repetition lowers coordination costs (section 7.2-7.4) suggests a less clear-cut relation between, on the one hand activities and interdependencies, and coordination modes on the other, hand than proposed by the theoretical contributions offered in chapters 2 and 3.

Firstly, in contrast to the contingency approach, it is indeed found that the causality runs both ways: coordination modes are adapted to activities and the other way around.

Secondly, when sequences of activities are not repeated, costs of identifying coordination modes can bring about a uniform coordination mode, even though interdependencies / the informational content of coordinating these activities varies.

Thirdly, when sequences of activities *are* repeated, due to specialisation, coordination modes may not be very sensitive to the dependencies between activities. Firms and individuals, who handle repetitive sequences of activities and hence, can use the same (combination of) coordination mode(s) over and over, increase their skills within this particular field. Specialisation of this kind makes firms and individuals more reluctant to change coordination modes, as they may prefer to use the present (pattern of modes), although they are aware of other - and in the absence of switching costs - more preferable modes.¹¹

Another aspect of learning and coordination relates to the particular skills developed by repetition due to a division of labour. As the sofa case illustrates (and in contrast with the claims of Thompson 1967), by a process of learning, it becomes possible to coordinate activities with a medium or high degree of interdependence with, from an information processing point of view, “light” coordination modes, such as norms or rules. This in turn challenges the view, that activities (with associated interdependencies) are to be the sole basic unit of analysis for studies on coordination. It appears that a temporal dimension relating to the skills and knowledge involved in, and created by, the process of coordination also have to be considered.

¹¹ An anecdotal story from the construction industry highlights this. Within the last five years or so, some of the major (main) contractors have expanded their activities vertically, meaning that they have all the major trades represented in-house. However, this development has not been accompanied with building projects conducted solely or mainly in-house. On different occasions I asked project managers, if they ever considered using the trades in-house in a more extended and systematic way than at present. The answer given was along the line: “Hell no! If something goes wrong with the external contractor, we can withhold payment or even get an arbitral award. But if it is in-house, what do you then do in case of a disagreement?” A possible interpretation of this answer is that in construction, the involved parties have knowledge and skills in writing contracts and in use of price coordination, and they have developed facilitating organisational structures (e.g. the court of arbitration). Hence, they find it very difficult to change to, say, coordination by teaming (perhaps) conducted in-house.

In general, it seems that the issue of how coordination skills can be improved over time does not appear to have drawn much attention in the existing literature on coordination. This study suggests that *learning* is a promising concept to dig into in order to understand the processes by which coordination modes are selected.

The simultaneous use of multiple coordination modes and their changeability

The case studies also bring nuances to the theoretical framework on activities and coordination modes by illustrating, how a single activity can be handled by a wide range of different coordination modes, and how coordination modes change according to phases of production, as well as hierarchical levels.

The work at hand provides an in-depth study of the coordination modes used during the production of a roof. To recall, it was found that *many different coordination modes* were used for *each activity*. This seems to challenge the view, that a sector using a particular technology (as proposed by Thompson 1967) or even an activity with certain properties (as proposed by Grandori 2000) can be classified by a single coordination mode.

The empirical investigation also reveals how coordination differs according to *organisational levels* and *phases* in the construction process.

For instance, at the level of the craftsmen, instructions from the foreman or the clerk of work define when to perform an activity (i.e. coordination by authority). The foreman and the clerk of work base their instructions on unilateral decisions at the weekly site meeting and on the instructions from project management. Thus, at this organisational level, the coordination of when to perform an activity is done by different modes (some degree of teaming is used) and by different actors (project management).

The sofa case shows how coordination modes change for different phases. In the initial design phase teaming is used. When the team has reached an agreement (and one or two prototypes have been produced), the employees are told what to do through directions, i.e. in the beginning of a product cycle coordination is done by authority. However, as the employees become acquainted with the activity (which is usually a swift process, as the activities they perform are almost

identical from one type of sofa to another) coordination by norms (e.g. routinisation) takes over. Similarly, in construction, most decisions (in the design team) during the planning phase are, or at least appear to be made unanimously in the design team. Later (during execution), these decisions are forwarded to the craftsmen as instructions to be followed.

The fact that coordination modes used for a single activity will often differ according to the organisational level and according to the phases of production further stresses, that sectors, firms or even activities cannot easily be classified by a single coordination mode. Consequently, the study of coordination practices is - at least until any regularity in the combination of coordination modes at different levels have been identified - a myopic affair. Furthermore, this also points to the importance of being very specific about at what organisational level and in what phases of production coordination practices are studied.

Chapter 8 – Empirical perspectives: the characteristics of construction revisited

8.1 Introduction

This thesis has addressed a set of rather specific questions relating to specialisation and coordination within the construction sector. In pursuit of these questions, elements of a more general understanding of the construction sector have been developed along the way. Potentially, this understanding can shed light on a wider range of organisational issues than the ones studied in the three research questions.

This chapter is devoted for these wider empirical perspectives. Even though each of these perspectives probably deserves a thesis in their own right, I hope to show how a range of phenomena (elaborated on below) that intuitively seem surprising or perhaps even disturbing or alarming (or in economic terms "inefficient") appear more reasonable, when information costs are taken into account. Put differently, this chapter readdresses some of the major characteristics of construction mentioned in chapter 1 (section 1.4.2). But rather than taking these characteristics for granted or seeing them as fundamental, in the following I try to explain them largely as consequences of market fluctuations.

These reflections however do not answer the rather obvious question of if there is any room for improvement in the construction sector. The epilogue (chapter 10) is devoted to this question.

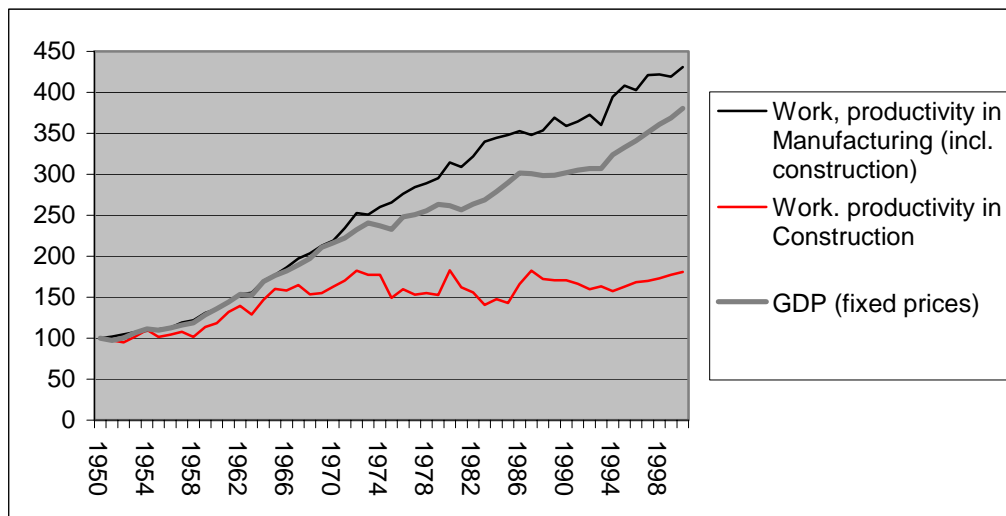
The discussion on how the general framework of the thesis can be used to explain some key characteristics of the present organisation of construction is structured as follows. Firstly, potential reasons to low levels of productivity and growth are considered. Closely related to this issue, follows a discussion on innovation in the sector. Thirdly, I offer some explanations to the dominance of many small firms within the construction sector. Trust is the fourth issue that is briefly analysed. And finally, reasons to ad hoc planning, overspending and poor quality are examined.

8.2 Key characteristics of construction and its performance – some explanations

Productivity and growth in construction

Figure 1 illustrates the increase in productivity (the outcome versus income ratio) for different segments of the economy from 1950-1998.

Figure 1: Labour productivity for different sectors, Denmark 1950-2000 (1950=100)



Source: Statistical 50 years review 2002 and calculations by Dan Ove Pedersen, The Danish Building Research Institute.¹

Even though one has to be careful with productivity measurements based on this kind of aggregate data, the figure clearly suggest that the overall improvement has been lower in construction than in manufacturing. In light of the argumentation of the present work, this is not surprising. As emphasised by Smith, a fundamental source of gains in productivity is the division of labour. In fact, the difference between productivity increases in construction and manufacturing is neatly explained by a mild paraphrasing of Smith's explanation of how seasonal changes bring about a more limited division of labour within agriculture than manufacturing:

" [The] impossibility of making so complete and entire a separation of all the different branches of labour employed in construction [originally "agriculture"] is perhaps the reason why the

¹ I thank Dan Ove Pedersen for making these data available to me.

improvement of the productive powers of labour in this art does not always keep pace with their improvement in manufactures.” (Smith 1970, p. 111).

Now, seasonal changes have not been of main concern in this work (even though its impact on construction can not be totally ignored). Rather, the present work has stressed change in *aggregate demand* as an important source of limited repetition of sequences of activities, which in turn results in a limited division of labour. Besides, for the theoretical and empirical reasons given throughout the thesis, this claim seems to fit well with the observation, that the decline in productivity within the construction industry (and thus, the time where the gap between productivity of construction and manufacturing seriously widens) began at the time of the first oil crises in Denmark (1973) when the unbroken post war improvements of GDP came to an end.²

Innovation in construction

According to Smith, one important element of the division of labour is that it allows for innovation of working procedures and machinery that facilitates production. The present work also adds insights to this claim by pointing to the different ways in which lack of repetition in construction can be an impediment to innovations in processes and products.

The importance of “being alike” makes it less attractive for firms to develop idiosyncrasies that change their interface with other companies. Or put differently, if, say, a firm by will or by incident discovers a way of reducing the costs of performing an activity, implementation of this idea has to be counterbalanced with either the coordination costs imposed by doing things differently or with the costs related to lack of adaptability to new working constellations. This leaves the innovative firm with two options: should it (a) stick to innovations that do not alter its interface with other firms; or (b) try to promote / wait for simultaneous change in the behaviour of its partners. With respect to (a), the possibilities of doing so are usually limited due to the short string of activities internalised in firms working in temporary interfirm organisations.

² An additional explanation for the halt of productivity improvements in construction in the beginning of the 1970s relates to a more ideologically motivated shift from large high-rise buildings to small-scale low-dense housing (Bertelsen 1997).

Concerning (b), change in the behaviour of a few collaborative firms is not enough, as the constellation of firms changes from one project to another. Hence, it appears that a rather large subset, and perhaps even the whole sector, has to change at the same time in order to allow for new interfaces.

In essence, it seems that in industries where it is important to behave in according to the norms and rules of a trade, the ratio of *systemic innovations* (i.e. innovations requiring simultaneous change in many parts of a system) is higher, than the ratio of *autonomous innovations* (i.e. innovations that can take place in one subsystem without changes in other subsystems); autonomous innovations being either *interfirm innovations* (i.e. innovation between specific firms) or *intrafirm innovations* (i.e. innovation taking place solely within a single firm).

Since firms and individuals within the same trade will behave more or less identically, introduction of a superior solution by a single firm, that gradually outperform less innovative firms, are not very frequent. As the “name of the game” is to provide identical solutions, a competitive edge can only be obtained on *prices*. In construction, the dominance of sheer price based competition is institutionalised in the tendering systems, where bids are mostly given for, in principle, fully described jobs; that is construction firms *are not allowed* to come up with bids that, apart from the price, differ from the bids of other firms.

The combined effect of (I) systemic rather than firm based innovations, and (II) competition based on prices and not on innovation, suggests a *low overall level of innovation* with low levels of repetition in sequences of activities. Since innovations will only be successfully implemented when they take place simultaneously across the sector, innovations that only take place in parts of the system are ruled out. Interestingly, this implies *coordination costs for innovation*. Secondly, as firms compete only on prices, presumably, they spend fewer resources on innovative purposes. Besides, discontinuity also limits the *possibility* of learning and in turn complicates innovation (Gann and Salter 1998).

Thus, shifting working constellations favour systemic innovations, that is innovations that take place simultaneously in the whole industry, or at least a large subset hereof.

An empirical study on the deviance in productivity across Danish industries (Madsen *et al* 2000) can be interpreted in favour of this line of reasoning. If systemic innovations are dominant, we would expect the deviance in productivity to be low across firms within the construction industry. And this is exactly what Madsen *et al* find; of the 18 sectors that the economy has been divided into, construction has the lowest deviance for manpower, and for total factor productivity in 1990 and the second lowest in 1996. Furthermore, to the degree that there is a difference in productivity between firms, it is not maintained (measured for an one and five year lag in the period 1990-97). After one year, the highest loss in advantage of productivity is found exactly within the construction industry and in a five-year lag the construction industry is second to last. The picture remains the same when analysed for small and big firms, respectively.

The common procedures (or isomorphism) of the industry – and as part of this the governmental regulation – can be perceived as an impediment to innovation (Pries and Janszen 1995). But to get the full picture, the essential role of these procedures with respect to lowering coordination costs should be kept in mind.

Similarly, the tendering system, where bids mostly are given for, in principle, a fully described job (construction firms are not supposed to come up with novel solutions), can be seen as a restriction to innovation (Goodchild and Chamberlain 1999, Miozza and Ivory 2000). But again, the tendering system is part of a way of organising, which lowers on coordination costs in an industry subject to radical external shifts in aggregate demand.

A third limitation to innovation can be ascribed to the separation of coordination and manufacturing. The final product is designed and to some degree coordinated by the architecture and engineering firms, but is produced by the construction firms.³ Further, the building materials

³ The degree to which coordination of construction activities is separated from production depends on the contractual form. In a traditional/separate trades contract, the coordination in the planning phase (by architects and engineers) and during execution (by project management) is placed outside the contracting firms. In a traditional main contract, the main contractor is responsible for coordination on site and consequently, coordination and production are in some cases taken care of by the same firm. However, as the main contractor in most cases makes use of a substantial amount of subcontractors, the extent of integration should not be overestimated. In a turnkey/design and build contract, the turnkey contractor is also responsible for the design and planning of the building. Yet, these are with

and building components made by the producers direct how a house can be produced, but once again, the house is built by contracting firms. This way of organising can have several advantages: firms can specialise in a limited span of capabilities, problems of shirking can be reduced with smaller firm size, and the benefits of integrating activities along the value chain is in any case limited due to the need for adaptability to external changes. However, the separation of (and as part of this, the lack of repetition in the relation between) design and production can, as illustrated in the discussion in section 7.3., limit hands-on experience as a source of innovation, as well as create incentive problems. Even in the presence of trades, it may be more costly for people without prior knowledge of each other, and thus without specific codes or standards for communication, to exchange information about, say, improvements in working processes. And indeed, the interest for doing so is limited, if there is not a new project in sight for which this improvement can be used. Furthermore, due to fragmented production (each firm only carries out a very limited subset of all activities) the odds are, that the improvement goes to other firms (Bowley 1966). If so, the firm that knows of and potentially can initiate an improvement, will have to balance the costs of doing so with the expected compensation given by other firms.⁴ Finally, the *absorptive capacity* (Knudsen 2001) – i.e. the ability to use the ideas of others – is most likely reduced in the manufacturing part of construction due to very limited presence of design offices and academics (Bougrain and Haudeville 2002)

Fourthly, as argued with reference to Casson (1994) in chapter two, it can sometimes be more costly to transfer information for decisions than to transfer a decision. If so, information is *decisive* and favours the existence

rare expectations performed by architects and engineers employed in separate firms, so once again, the extent to which coordination and production is integrated in the same firm appears to be very limited, even in this contractual form. Nonetheless, the fact that the producing firm (the turnkey contractor) has a contractual relation directly with the design team (rather than having an indirect contact via the client) may enable coordination. Thus, according to Moore and Dainty (2000, p. 44) “The reasons for the popularity of Design and build [in UK construction] seem to revolve primarily around its perceived ability to bring the design and construction processes closer together...”.

⁴ The expectation will of course depend on how well the market for this kind of information is working. However, it could be assumed to be far from perfect for a number of reasons. Firstly, by definition, the exact nature of this innovation is not known in advance and hence, is difficult to include in a contract *ex ante*. Secondly, as pointed out by Arrow (1973), markets for information can have imperfections as the seller cannot make the value of the information known to the buyer, without revealing the content of the information.

of an authority relation, with the person holding the decisive information as the superior. In the case of construction, information on market-change is likely to be decisive and thus, favours decisions to be made by the people who have this knowledge (but not necessarily have or pursue knowledge on production). So, if demand volatility is very high compared with potential changes in input or production, it may pay to completely ignore the two latter conditions and simply base decisions on knowledge on markets. Thus, when information costs related to decisiveness are taken into account, it may be profitable for firms deliberately to disregard potential improvements in production.

As discussed in chapter 7, this setting is likely to create a particularly low level of innovation within the firms specialised in production, i.e. within the construction firms. Firstly, construction firms are not supposed to innovate due to the price based tendering system. Secondly, they will only benefit from innovations, if these are in pace with innovations in other parts of the value chain on which the construction firm has little influence. Thirdly, construction firms are, for reasons discussed in the next section, usually of a limited size and without the presence of academics (who, as learned in chapter 5, are concentrated in the coordinating firms of architects and engineers); conditions that may also limit innovation. Rather, innovation, is expected to take place in the coordinating firms and perhaps also, due to their size, in producers of building materials. A survey focusing on, among other things, innovation in Danish firms in the period 1993-95 seems to support this interpretation (table 1).

Table 1: Innovation in selected industries – the DISCO inquiry⁵

	Not innovative	Innovative in the firm	innovative in Denmark	Innovative Globally
	Percentage			
Firms of architects and engineers (n=38)	41,46	53,66	0	4,88
Construction firms (n=249)	77,65	19,61	1,96	0,78
Producers of building materials (54) ⁶	44,44	27,78	16,67	11,11
Furniture firms (n=52)	26,92	61,54	5,77	5,77
All firms in survey (n=1867)	49,24	38,64	6,69	5,43

Source: Own Inquiries in DISCO database 2000

As seen, the level of innovation in construction firms are way below the level of innovation in firms of architect and engineers and of producers of building materials – a finding that also seems consistent with the very rudimentary questions asked on innovation during the case study.⁷ Although innovations are concentrated in this latter, and small, group of firms, innovation is not much beyond the average level of innovation in all industries, which supports the previously stated claim, that innovation is low in construction. The innovative rate of furniture firms is included with reference to the discussion of sofa producers in chapter 4. A possible interpretation of the figures is that sofa production, which in many ways resembles roof production, is significantly higher, because a more stable environment allows for repeated sequences of activities, which in turn enables specialisation and the division of labour.⁸

⁵ These figures are based on inquiries in the DISCO database (I thank Anker Lund Vinding for access). The DISCO-survey is based on a questionnaire submitted to 4000 firms in the summer of 1996. 1900 firms responded, with 684 firms belonging to the manufacturing industry and the remaining 1216 belonging to the service sector. As part of the questionnaire, the firms were asked, if they in the period 1993-1995 had introduced new products or procedures (Gjerding 1996).

⁶ In this group, firms with Nace value 26.30.09 (tiles, cement, and concrete) and 28.10.09 (building materials in metal) are included.

⁷ As innovation is not a core feature of this thesis, questions relating to this were not systematically pursued during the case study of roof construction. However on five occasions (i.e. for five activities) a plumber, a crane driver, a person doing the roofing felt and two different carpenters, respectively were asked if they during this or previous building projects, had experienced that they, or some other persons working on the site, had changed their way of performing activities. In all five cases the answer was “no”.

⁸ Hillebrandt (1975) discusses the impact of change in demand on the level of innovation as a balance. Periods with variance in demand will at one hand increase innovation, since “rapid technological changes were produced in the booms which were consolidated in the depressions when attention

The argument presented so far could support that no innovation what so ever takes place in construction firms. But as seen in table 1, after all, this is not the case. In a study of the residential construction industry in the U.S., Slaughter (1993, 1993b) identified 34 innovations to a specific new technology (the stressed-skin panel). Her overall argument is that the construction firms, and not the manufacturer of building materials, are the source of most innovations. And thus, her general claim is that the innovative activity of contractors is underrepresented by concentrating on manufacturing products alone. This critique seems reasonable if resources spent in independent R&D-labs, patents or articles in scientific journals (as used by Pries and Janszen 1995) are used as proxies for innovation. Yet, it seems less obvious that the DISCO-survey – in which firms not unlike Slaughter’s approach, are asked directly, if they have introduced or used any new products or processes – should be particularly vulnerable to this critique.

Nonetheless, Slaughter’s study is very informative of the kind of innovations executed by contractors. Where the innovations of manufactures were confined to the stressed-skin panels themselves, contractors’ innovations allowed the panels to work in conjunction with other building systems. The *raison d’être* for contractors to engage in these innovations was mostly to ensure continuation of the building process. Rather than waiting several weeks for a modified panel, in a few hours, contractors could come up with an innovation that allowed the original panel to be used for situations not considered by the manufacturer. Besides potentially illustrating hands-on experience as an

could be concentrated on cost reducing changes.” (ibid, p.55). But at the other hand, it will be the traditional type of contractors rather than the innovative ones that tends to survive because they have the lowest overhead costs. Hillebrandt find it “difficult to access the balance of the two tendencies”. The observations and reflections offered in this thesis seem to suggest, that the impact of the latter outweigh the former tendency. Furthermore, in the PPB-consortiums I observed that even though the idea was to build many projects, most parties within the four consortia’s found that break-even for innovative costs should be reached on the first or, at the very least, the second project. This observation does not support Hillebrandts idea that construction firms engage in innovative activities disconnected from ongoing specific building projects. Similarly, Baark find that specific clients significantly determine the innovative routines of the engineering consultancy firms of Hong Kong. Additionally, Nedo (1978, p. 71) concludes that the construction sectors willingness to train men is harmed by change in demand. as the “men coming forward for training must have the expectation that they will be able to get a long term benefit from that training, and the industrialist must have an expectation that he will be able to make a return on, and in due course, recover his investment”. The effect of decline in demand exceeds the actual period of decline as confidence in future growth takes time to establish and even then, a number of years are required to regain capacity.

important source to innovation, this observation emphasises the problems of changing one part of the building process without changing other parts as well (Slaughter 2000). Due to a highly skilled and experienced workforce, contractors can often, to some degree, remedy problems of uncoordinated innovations, but it is doubtful whether the manufactures lack of information, control and responsibility for the activities performed on the site strikes an appropriate level of innovation (Slaughter 1993). Perhaps it is not coincidental that Pries and Janszen (1995) in a study of innovations in the Dutch building industry in the post-war period find, that since the introduction of the large-scale concrete-casted systems in the mid-1960s, innovations have tipped in favour of being conducted in cooperation between multiple firms, rather than being performed by single firms.

Using the terminology of Weick (1976) Dubois and Gadde (2002) argue that construction consists of tight couplings in individual projects and loose couplings in the more permanent network, e.g. the network between projects and firms. A system of standardised (and thus loosely coupled) organisational units enables coordination and short term productivity. At the same time, the loosely coupled system make each construction site an “experimental workshop” (ibid., p. 628) with a lot of local adaptations. However, the same loose coupling also prevents the diffusion of novel solutions and hence all in all reduces innovation and learning. This observation seems to be consistent with Slaughters in the sense that at the level of the building site, construction is highly innovative, but since innovations are rarely diffused to other projects or to the permanent part of the firm, at higher levels (the firm or the sector) construction is not very innovative.

Even though there for quite a few years has been somewhat of an obsession with the idea of “industrialising construction” (see for instance Diamant 1968, Kjeldsen 1988), the line of reasoning provided here favours a cautious view on the possibility and desirability of moving production from “the site to the factory floor”.⁹ As emphasised in the summary of the empirical part (chapter 5), building materials that are

⁹ Here, I do not consider the wider issue of whether industrialisation equals large-scale and monotonous buildings (or cities for that matter) of a poor architectural quality. Undoubtedly, these and more ideological issues played an important role, when the expansion of prefabricated high-rise buildings came to an end in Denmark in the beginning in the 1970s in favour of low-dense (and diversified) buildings (Bertelsen 1997).

not yet cut into size or assembled for final use (i.e. materials with a limited degree of prefabrication) can be adjusted to interdependencies that are impossible or too costly to foresee in one-off projects. Or to put it differently, a lower degree of prefabrication may increase production costs, but conversely decrease information costs related to coordination. Perhaps, this is why construction after many years of intensive efforts (In Denmark especially in the period 1947-1972) in favour of prefabrication and large-scale production still is characterised by a substantial degree of on-the-site adaptations and small-scale production (Nam and Tatum 1988, Bertelsen 1997).

The existence of many small construction firms

As noticed by Eccles (1981b, p. 450): “One of the most striking features of construction is the large number of firms”. The framework presented here provides a set of explanations for the continuous existence of the many small firms; thus, this feature is perhaps still striking, but is a little less mysterious.

Eccles rooted his claim in his study of homebuilders in the U.S. in the late 1970s (although he consulted more general statistics as well). However, the questions seem to be relevant for a much wider field of construction activities; Slaughter (1993) also points to the existence of many small firms in the U.S; Pries and Janszen (1995, pp. 43-44) make “the great number of small enterprises” a general characteristic of “European” or “Western” construction; fragmentation is a feature of the traditional organization of construction in the UK (Miozzo og Ivory 2000). And, as pointed out in chapter 5 of this thesis, construction firms are indeed small. Not only due to a higher mortality rate of construction firms, but also because the firms that do survive, expand less in size than manufacturing firms.

The question why small firms are so common in construction is intriguing as such. However, it may also form part of the explanation for, and perhaps improvement of, the performance of the industry. According to the general statements of K. Foss (2001) and Casson (1997), the existence of many small firms and a fragmented building process, in which each firm is only performing a very limited set of activities, may explain the low level of innovation in construction (Slaughter 1993, Connaughton *et al* 1995, Miozzo and Ivory 2000).

To some degree, fluctuations in overall demand can directly explain the existence of many small firms. Steep down-swings force construction firms out of the market, and thus construction firms are in general younger than manufacturing firms. And as firms usually start small and then grow, this affects the average size of firms. However, this is not the only explanation. As also seen in chapter 5, construction firms start smaller and (in absolute terms) grow more slowly than manufacturing firms. In order to provide an explanation for this observation, it seems necessary to consider the impact of changes in overall demand on the way construction firms are organised.

One obvious reason for the limited size of construction firms relates directly to a core argument in this thesis. Due to external changes, it is not profitable for firms to internalise repeated strings of activities within the firm. Thus, it could be hypothesised, that an important element of a larger size of manufacturing firms is that their *raison d'être* is to provide stability to a span of activities by placing them under the direction of specialists in coordination. However, this is not the case in construction, where firms - roughly speaking - only carry out a single activity in the value chain at the time (recall figures 1 and 2 in chapter 6). Accordingly, construction firms can work efficiently even when they are very small.

The limited benefits of integrating repeated sequences of activities in construction may explain the difference in size between *newly* established construction and manufacturing firms. However, it is less clear how this argument accounts for the fact that manufacturing firms grows more than construction firms *over time*. Here, the Penrosian argument on growth of the firm elaborated on in chapter 2 (section 2.6.) seems more obvious. As seen in the sofa case, repetition of activities frees managerial resources that can be devoted to new activities and thus, the firm can expand its activities. In roof production, resources of managers are only freed to a very limited extend, and thus expansion of the firm size is likely to create information overload of managers (i.e. at the superior layers) or, as an alternative, the introduction of more hierarchical layers, which in turn can create other information related costs due to a large span of control (see also the discussion on authority in appendix B).

In essence, the existence of many small firms in construction may seem odd and even adverse to the operation and development of the

construction sector. But the small firms are part of a system geared to encompass the fluctuations created by change in overall demand.

Low levels of trust in construction

As mentioned in chapter 1, one key characteristic of the construction sector is often believed to be low levels of trust and high levels of conflicts (Korzynski 1994, Loosemore 1998, Loosemore 1999).

Perhaps for the same reason, trust is nearly always emphasised as an important ingredient of partnering – see for instance typical partnering definitions provided by Latham (1994, p 62), Matthews (1996, p. 119); Barlow et al (1997, p. 6) and Blak (1997, p. 49), Bennet and Jayes (1995) and Bennet *et al* (1998) (or Madsen and Olsson 1995 or Thomassen 1999b for an overview).

Surprisingly, much of the literature on partnering is not very specific on how mutual trust is created – or why it is not there in the outset. This thesis provides some pieces to the answer of the second part of the question (and hence indirectly also to the answer of the first part).

Trust can be defined as “*An expectation of a manager that his (potential) business partner will not act opportunistically – even if he holds no power over him to ensure that he behaves*” (Lorenzen 1998, p. 11). Underlying this and other definitions is usually rather fierce discussions on whether trust is a rational phenomenon or not (Swedberg 1998). See for instance the debate between Williamson (1985 and 1993) – who considers trust to be calculative – and some of his opponents Coriat and Guennif (1998), Baudry (1998) and, as indicated in his definition of trust, Mark Lorenzen (1998). Similar reflections are implicit or explicit found in some of the general works on the reason to the existence and erosion of trust, see for instance Weber 1995, Hollis 1998, Fukuyama 1998, Hansen 1998.

The following argument will be based on the assumption that trust is created or at least maintained by the bounded rationality of people.

The preoccupation with trust in much of the economic literature has to do with the economic benefits that trust is supposed to create. Dodgson 1996 and Lazaric and E. Lorenz (1998) argue that trust is essential to learning and innovation, as it is very difficult to write complete contracts for an relation aimed at providing something that is not known in

advance. Arrow (1974, p 23) takes it one step further and argue that "trust is an important lubricant of a social system" (p. 23)

So, besides being a characteristic in its own right, the existence of low trust also elaborate on some of the other issues discussed in this chapter, in particular the low level of innovation and learning and the poor level of coordination.

But if trust is so beneficial, why isn't it always present? An answer consistent with the assumption that people behave in a bounded rational way would be that even though trust and cooperation offers the best overall outcome, cheating/non-cooperation still pays off seen from an individual point of view. If this is true, we are in a *prisoner's dilemma* situation.

The prisoner's dilemma is essentially a situation where two persons – not knowing the decision of each other beforehand – individually have to decide whether to cooperate (=displaying trust) or to defect. The payoff each part receives depends on his own as well as the partner's decision. The properties of the prisoner's dilemma are shown in table 1.

Table 1: The Prisoner's dilemma.

		Player Y	
		Defect	Cooperate
Player X	Defect	2 \$ each (4\$ total)	6 \$ for X 0 \$ for Y (6\$ total)
	Cooperate	0 \$ for X 6\$ for Y (6\$ total)	4 \$ each (8\$ total)

Seen from an individual point of view the best strategy in a single-shoot prisoner dilemma game is to defect, no matter what the other player is doing. If the other player is cooperating one get 6\$ by defecting

compared with 4\$ for cooperating. If the other player is defecting, one gets 2\$ and not 0\$.

Inevitably, the result is defect-defect if each player seeks his own benefit. This is not a nice outcome from an overall point of view. Defect-defect only creates values for 4\$, which in this example is only half of the overall maximum cooperate-cooperate output.

One way out of the prisoner's dilemma is to repeat the game.

Rapoport and Chammah (1965) find that people show a strong tendency to cooperate when the play is repeated with the same partner. This observation has been supported by Axelrod that finds that a tit-for-tat strategy – a strategy formally defined as “cooperate on the first move, then on each successive move do what ever the other player did on the previous move” – will be the dominant strategy in computer simulations against a number of other strategies (Frank 1988, p.p. 29-35). Axelrod specifies that some conditions have to be met in order to assure cooperation; i.e. the set of players have to be reasonably stable, each player can remember what the other players did in previous interactions, players have a significant stake in future interactions and no one amongst the players knows exactly how many times they will interact with each other (Frank 1988, p.p. 29-35).

The importance of repeated games is actually not a new insight. In a paper from Adam Smith from 1766 we learn that (Smith 1766, op. cit. Klein 1997, p. 17):

“A dealer is afraid of losing his character, and is scrupulous in observing every engagement. When a person makes perhaps 20 contracts in a day, he cannot gain so much by endeavouring to impose on his neighbours, as the very appearance of a cheat would make him lose. Where people seldom deal with another, we find that they are somewhat disposed to cheat, because they can more by a smart trick than they lose by the injury which it does their character.”

Experimental economics have supported the positive impact of repetition, especially if the value of cooperation is relatively high compared with the payoff for defection (Ledyard 1995)

Another result from experimental economics is that communication enables cooperation. Even though the dominant strategy (from an

individual point of view) in any case is to defect, people who are given the chance to communicate before they participate in an experiment with a public-good investments like the prisoner's dilemma will be much more cooperative (Ledyard 1995).

Davis and Holt (1993) find that the impact of communication in particular is high when it is allowed initially. In experiments where communication were allowed in the first period of the game, contribution rates continues to be high in many periods with no communication while contribution rates only increases slowly when communication is introduced in the second period or later.

This is "bad news" to construction. Repeated games are not very frequent in construction. The need for adaptability does not encourage long-term relations between specific firms or individuals. Additionally, low survival rates and the existence of many small firms makes it less likely that construction firms by chance will meet again.

Lack of repetition and many hierarchical layers induce "noise" (Balton, P. and M. Dewatripont 1994) and thereby reduce the value of communication. Furthermore, the scattered (in time and physically) work in particular on the construction site does not enable in particular the initial communication that is essential for trust building.

Thus it seems that the partnering literature is right when it points to the problem of trust. But it also seems that trust is not so much a cause as a consequence of more fundamental organisational aspects of construction. Creating trust in this organisational set up does not appear – no matter how much the positive effects of trust is highlighted in teambuilding seminars and the like – to be an easy job.

Ad hoc planning, delays, overspending and poor quality in construction

One of the initial reasons why I became interested in the construction process was the experience as a client in a social housing organisation, that building projects were usually over time and budget, or were only kept on time and budget by last minute cuts and quick (and not always thoroughly considered) solutions on the site.

Unfortunately, this observation does not appear to be confined to the social housing organisation in which I worked. The list of "project errors" in the case study is lengthy and at the same time, the carpenters

do not consider this building project to be any worse than the majority of projects they had worked on. Additional sources also seem to support that construction projects are difficult to handle regarding timetables, spending (Skamris 2000) and quality (Byggeskadefonden 2001).

In a study of 5510 communication events in four Swedish building projects, Carlsson and Josephson find that a substantial part of communication is devoted to changes or errors in the project (Table 2).¹⁰

Table 2: Reasons for communication on four Swedish construction projects

Reasons for communication	%
Coordination, planning, scheduling etc	17
Give or receive information or document	22
Give or receive explanation due to changes	22
Receive or give explanation due to errors	15
Receive or give information about decisions	13
Other	11
Total	100

Source: Carlsson and Josephson 2001

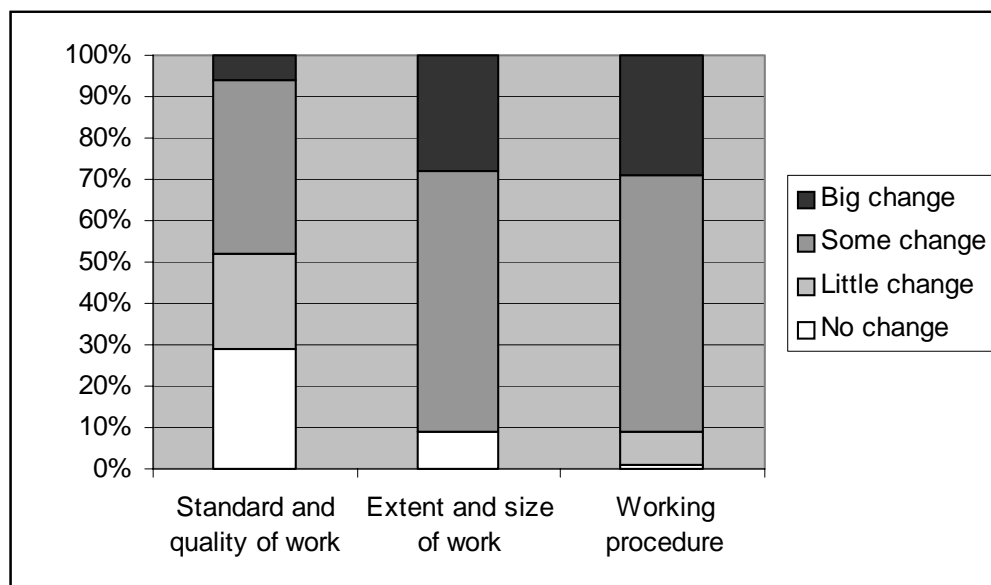
The level of information related to changes and errors (and perhaps also to decisions) indicates that construction is not about simply carrying out a thorough plan taking anything into account, nor is it a matter of only following well-known procedures from previous projects. Rather, as novel and anticipated events occur, a lot of adjustment is done as the building process evolves. A study on the distribution of the 7853 working hours spent by consultants (engineers and architects) and contractors on a refurbishment project in Odense (Funen, Denmark) confirms this picture. Of the 16,5% of the time spent by consultants and contractors on managing the building site (83,5% of the time was spent on construction), only one quarter (4,5%) was spent during the planning

¹⁰ The study is limited to communication *between* client, architect, structural designer, installation designer, contractor, installation contractor and material supplier. For each of the four building projects one to three key persons were identified as representatives for each group of actors (52 persons in total). These persons themselves registered the information in a special diary combined with interviews on how time was spent on each formal meeting.

phase, whereas three quarters (12%) was spent on execution and handing over of the building (Bertelsen 1996, 2002).

In the same study, the magnitude of changes (weighted according to the expenditures) was estimated by comparing the contract with the finished product, that is the refurbished house as handed over to the client. Although the results naturally depend on the criteria used for assessing changes, the results reported in figure 2 support the view of significant *ad hoc* changes.¹¹

Figure 2: The level of change (% of expenses) from contract (tendering) to handing over in a refurbishment project in Odense, Denmark. %



Source: H. Bertelsen 2002

Changes are particularly high with respect to extent and size of work, as well as for working procedures. The *relatively low* (but in absolute terms still *high*) level of change in standard and quality could be explained by a predominant use of output contracts (as also observed in the case study on roof construction).

¹¹ The procedure for this inquiry was as follows. First the contract written by the architect as part of the tendering process was split up according to different parts of the house. Then at the time of the handing over the refurbished house, the actual solutions used for these different parts were written down. And finally, the original description was compared with the actual solutions and the deviations were, based on an assessment made by the researcher, grouped in four categories ranging from no to fundamental changes.

But why is construction apparently coordinated this poorly? The framework established here suggests that, at least to some degree, efficiency explanations to the level of coordination in construction can be given. Due to change in external demand, the benefits from repeating sequences of activities between the same individuals working within a firm or in continuous relations between firms is limited. This encourages temporary interfirm organisations formed for a particular project. As interactions are not repeated, the costs of *getting* information become more important than *the costs of not having information*. And in this way the resources spent on improving information *ex ante* production may not be justified with the savings made by better planning *during* production.

However, there may also be less justifiable (from an welfare economics point of view) reasons for problems with complying with budgets, timetables and quality standards. For instance, the lack of information on the true difficulties of an assignment can create the *winner's curse* syndrome in which the contractor with the most optimistic (but often wrong) estimation of the assignment wins the contract. Consequently, the tendering system does not necessarily reveal the real costs of production. At the same time incomplete information also increases the room for *asymmetric information*. The contractor may use such an asymmetry in his favour to claim extra payment. This may balance the losses due to the winner's curse, but nevertheless implies an unproductive exercise of finding and in some cases maximising the effects of, say, deficits in the plans (as in the roof case, where the carpenters in order to claim extra payment completed the roof house in agreement with the contract knowing fully that the solution did not work and had to be reworked). Besides surpassing budgets, asymmetric information may also create problems with respect to the quality of the work, which can be hard to monitor by project management and by the client.

The flow of work on a construction site is not very steady due to changes and changes and the many parties involved.¹² This results in an

¹² The way delays build up in a chain of production with many working stations (each working station producing a, within limits, random amount of output) is vividly illustrated in the so called "game-of - parades".

inevitable conflict between deadlines for the project at one hand and high utilisation of resources of the single company - that can be achieved "...by a sufficiently slow rate of progress, so that there are always tasks on which the resources can be deployed" (Bishop 1975, p.67) - at the other hand. So unless some kind of penalties for delays is introduced, it will usually be in the interest of the single contractor to be behind the timetable. Another consequence with respect to delays of the uneven workflow is that contractors tend to work on multiple projects at the same time. This makes it difficult for the project management to plan and control how much work the contractors perform on their particular site.

Chapter 9 - Summary and conclusion

9.1 Research questions

This thesis has studied patterns of specialisation and coordination in construction. Three interrelated research questions have been considered by means of theoretical reflections and empirical studies:

- Research question A:** How is the division of labour in construction and what are the consequences hereof with respect to coordination?
- Research question B:** What are the roles of construction firms with respect to coordination: does coordination take place within or between firms and what limits that activities are handled within a single firm?
- Research question C:** What particular coordination modes are used for construction and how do they cope with the activities involved in construction?

9.2 The theoretical field

This thesis has been an inquiry into theories on a fundamental concept within organisational economics: the concept of coordination. Theories on coordination relate to *why* coordination takes place, by *whom* it is done, and *how* it is conducted.

At a more general level, the work at hand has aimed at providing insights into the theoretical field of *organisational economics*, i.e. the comparative assessment of the cost of producing and allocating resources by different structures of ownership and coordination. In particular, weight has been given to *information* aspects of organisation, and hence, the incentive based approaches (e.g. Transaction Costs Economics) have not been explored theoretically (although incentive aspects are occasionally hinted at in the empirical analysis).

9.3 The empirical field and method

The primary source of data has been a case study on the construction of a roof in a multiunit social housing project.

As a thorough understanding of the activities, coordination modes, as well as persons and firms involved in the process of coordination was needed, only a limited part of the construction process could be made subject to a case study. The roof was chosen, because it is one of the final parts of the construction process whereby the relation to other parts of the process could be studied as existing, rather than expected phenomena.

Because empirical studies of site organisation are sparse, in particular with respect to coordination practices, primary sources were used for answering the research questions. As a range of formal (e.g. authority exerted by written documents) and informal ways (e.g. teaming, where craftsmen on the site talk and agree on solutions together) of coordinating construction activities are studied, fieldwork *on the site* was necessary. During this fieldwork, all activities involved in roof construction were mapped out by observation, and the people doing these activities were interviewed according to the empirical research questions.

The people involved in the case study did consider the division of labour, the organisation of coordination and the coordination practices to be general to the house-building sector, with the possible exception of very small (single-house) projects and refurbishment.

Statistical data (partly provided by the unique Danish IDA-database) was used to illustrate changes in aggregate demand, and to investigate how these overall changes correspond to a low level of repetition in the relation between firms and individuals, respectively. Further, indicators of the organisational responses to low levels of repetition (as more thoroughly examined in the case study on roof construction) were derived from the IDA-database.

9.4 The empirical findings

Having in mind that generalisation from the case study relates to theoretical propositions or claims (“analytical generalisation”) - and not to populations (“statistical generalisation”) - the empirical findings of the study offer the following description and interpretation of specialisation and coordination in the construction sector.

The process of construction faces a low level of repetition at the macro level (created by unstable markets), which is further accentuated towards the micro level by the specifics of each building project. This inflicts a high degree of novelty to the building process, because firms, individuals and interdependencies between activities differ from one project to another, in spite of the fact that final products and in particular their sub-parts are not necessarily very different, and that the employed technologies appear to be very stable. The combined effect of non-repetitiveness at the macro and micro level is a key to understand the division of labour, the organisation of coordination and the coordination modes used in the process of construction (the three research questions).

Research question A

In general, the frequency and amplitude of fluctuations in demand for construction is likely to establish a situation, where the benefits of specialisation to a lesser degree outweigh the benefits of adaptability obtained by using stable and homogenous knowledge, common to a large and well-defined group of people and firms (i.e. *trades*). The benefits from this limited and non-firm-specific division of labour applies to the level of the sector, the firm, the project, and the individual:

At the *sector level*, homogenous and in particular stable knowledge facilitates the entry - and thus also the exit - of people employed outside construction. Consequently, common practices are an important prerequisite for the overall workforce adjustments critical to the construction sector running smoothly.

At the *firm level*, knowledge that is not targeted at specific common practices makes it possible to engage in new working constellations depending on demand. As the only safeguard to market fluctuations is to keep the door open to all kinds of projects, specialisation in particular

products and / or working constellations is hard to maintain. Investing in specific firm relations is further discouraged by the high entry and exit rates of construction firms. In addition, it becomes less difficult to establish construction firms, if new firms do not have to penetrate long lasting firm relations, or catch up with continuous improvement brought about by specialisation.

At the *project level*, delays are handled by working on multiple parts of the house and on multiple building projects simultaneously. The importance of minimising the adverse effects of delays by lower degrees of division of labour is presumably advanced by the limited possibility of routinisation or substitution of activities upstream in the value chain.

And finally, at the *individual level*, common practices increase job mobility and thereby minimise the risk of long-term unemployment in the likely event of staff reduction or closing of the firm. Even when employed within a firm, it probably pays for the employee not to be too specialised in particular activities, since this gives the firm higher degrees of adaptability between and within a project.

The existence of these highly skilled and homogenous groups of individuals and firms organised in trades do not only balances the benefits of specialisation with the benefits of adaptability. The organisation in trades also enables coordination.

Firstly, the skilled craftsmen can handle activities associated with different parts of the building, as well as activities that are not identical from one project to another, due to variations in working constellations, the final product and interdependencies of activities. In this way, a substantial degree of coordination is done by the craftsmen, who decide locally which tools and working procedures to use. Since skills are required for this decision-making, a jack-of-all-trades craftsman and firm is hardly conceivable; the complexity of the activity sets an upper, as well as a lower boundary to the level of the division of labour.

Secondly, it is costly to standardise working procedures and in- and output for activities, which are not repeated often. Hence, a promising way to decrease the variations in output, and consequently, to some degree reduce activity complexity in subsequent operations, is by combining decentralised decision-making with uniform skills. So although each craftsman due to this *craft production* has some degree of

freedom with respect to how he will carry out his activity, the fact that the same skills are used irrespectively of the specific person or firm, give the next person in the value chain some idea of what he can expect. Hence, the efforts to specify the outcome or working procedures of an activity can be reduced.

Research question B

As demand fluctuations favour the ability to switch from one value chain to another, and to switch from one part of the value chain to another, it is less likely that construction firms will devote their resources to being good at a particular string of subsequent activities. Rather, they will work on different parts of the project, as well as move from one type of project to another.

Since coordination only to a very limited degree is internalised in the construction firm, interfirm coordination is substantial. For the same reasons as it is disadvantageous to internalise construction activities, the benefits of engaging in bilateral interfirm relations are limited. Thus, even if repetition of firm constellations from one project to another occasionally occur (as it did in the case study of this thesis), it is rare that firms and individuals in construction invest resources in developing interfirm specific assets.

Furthermore, coordination by a third party solves many of the information problems created, when many firms scattered around in the value chain work together on a temporary basis as subcontractors. Centralisation of transfer and processing of information at one or few third parties is a way to economise on information costs. Moreover, incentive problems – which could be severe due to low repetitiveness, subcontracting and asymmetric information – are probably reduced with a mediating third party, and through the specification of output in combination with monitoring on the site.

Finally, as standardisation or routinisation is not encouraged in an environment with low repetitiveness, the job of coordinating construction remains challenging in all phases of the project, as well as from one project to another. The need for an advanced coordination effort promotes individuals and equipment specialised in this field. And

in addition, as competences become more particular, they may become more difficult to encompass in the same firm.

Research question C

A combination of modes is used to coordinate construction activities. The overall pattern at the level of craftsmen is that firm-based authority is used to specify which activities to do when. The input (which materials to use) and output (how much and what to produce) is determined by the information provided by architects and engineers (the design team) employed in separate firms. And finally, the specific working procedures and tools are selected by the craftsmen according to their skills and experience.

As expected for a sector with high demand volatility, the construction activities of the case study are mostly characterised with low degrees of repetition, high activity complexity, and that the actions of many other actors have to be taken into account. The study supports that the information involved in this set-up is difficult to handle by any coordination mode. In smaller projects (like single-family housing) with fewer people involved, more decisions are left open to the group of trades working on the site (i.e. coordination by teaming). In the case study, however, coordination by instructions from the design team was dominant. These instructions occasionally enforced solutions that did not minimise on materials or working hours spent, nor provided the desired final result. In addition, as all interactions between the various trades working on the project were not taken into account by the design team, rework and lower “buildability” for trades further down the value chain was frequent. Nonetheless, the rather dominant use of coordination by authority allowed many actors to interact on a non-permanent basis at reasonable information costs.

Thus, on the one hand, the findings of the case study support the theoretical framework (chapter 3) on the cost of *using* different coordination modes. On the other hand, coordination practices do not differ much, even though the interdependencies of activities – and in turn presumably also the informational content of the activities – vary. Deviations from the stable pattern of coordination modes are only made in rather extreme cases. This apparently surprising use of stable

coordination modes can be accounted for by taking the cost of *identifying* and *creating* the appropriate coordination mode(s) for a given set of activities into account. As firms and individuals do not carry out completely identical activities on a recurrent basis, the importance of these set-up costs is significant. Hence, in order to minimise on these costs, it makes sense not to fine-tune coordination modes to each activity, even though the latter will reduce the cost of *using* coordination modes.

9.5 Theoretical contributions

The thesis has contributed to *theories on coordination*. Based on the empirical findings, three propositions - relating to the “why, whom and how” aspect of coordination, respectively - have been proposed:

Proposition A: The less repetitive sequences of activities are, the more individuals and firms are driven towards isomorphism rather than innovation and specialisation. Thus, the less repetition, the lower the level of overall innovation and the higher the ratio of systemic innovation.

Proposition B: Low levels of repetitive sequences of activities increase the ratio of coordination done by a third party firm (trilateral coordination), but decrease coordination organised directly between two firms (i.e. bilateral coordination) or coordination organised within a firm (i.e. unilateral coordination).

Proposition C: The more repetitive sequences of activities are, the more coordination costs are lowered due to not only to (I) lower costs of identifying appropriate coordination modes but also as an effect of (II) lower costs of using a given coordination mode, and (III) lower costs to defining activities in a way that they become easy to coordinate.

The observations also provide a range of more specific nuances to the theoretical framework presented in chapter 2 and 3.

The *firm* - in which coordinators are specialised in handling variations and workers are specialised in performing their part of a repeated

sequence of activities – has theoretically been found to be an important way of ensuring a division of labour in a setting subject to discontinuity. However, this representation of the firm did not in all cases fit well with the findings in the construction sector. Thus, the role of the producing firm in construction is more limited with respect to coordination, as it coordinates *between* but not *within* value chains. Coordination of the latter (within the value chain) is carried out by third party firms specialised in coordination.

Furthermore, with respect to the notion of the firm, a significant *overlap* between the “*incentive based*” and “*information based*” has been suggested theoretically as well as empirically.

Adam Smith identified repetition of *activities* as the source of the division of labour and *lower production costs* and thus, as a source of “wealth of nations”. This thesis has found repetition of *sequences of activities* to be another potential source of growth, since it lowers *coordination costs* (which again can allow for a greater division of labour and thus, lower production costs). Three such mechanisms to reduce coordination costs, that are not very different from the three production costs mechanisms identified by Smith (“*dexterity*”, lower switching costs, and innovation), have been identified. Firstly, repeated sequences of activities lower the costs of *identifying* and *creating* appropriate coordination modes (that is *switching costs* induced by going from a well-known to a less well-known sequence of activities are reduced). Secondly, repetition of activities lower the costs of using a given coordination mode, since the persons involved become more knowledgeable and experienced in using it (they increase their *dexterity*). And finally, due to repetition it becomes possible to define, or *innovate*, activities in a way so that they are easily coordinated.

The latter suggests that, in contrast to the contingency view, *activities are not given to firms*. Consequently, the way a product is partitioned into activities is an essential part of understanding the process by which *activities and coordination modes co-evolve*.

Further, the study has given empirical evidence on how the use of different coordination modes, as well as specific coordination modes can change *over time* and at different *organisational levels*. Among others, it has illustrated how authority changes as sequences of activities are

repeated. And how authority persists even in temporary and innovative organisations.

9.6 *Empirical contributions*

Finally, the thesis has provided an analytical frame and empirical observations that facilitates the understanding of present and potential organisational forms in construction. By this, the thesis contributes to the ongoing debate on how to organise the building sector.

The empirical contribution is to some degree captured in the three research questions discussed in section 9.4. But as seen in chapter 8, the framework also add insights to other issues within construction: (a) the level of productivity, (b) innovation, (c) the existence of many small firms, (d) trust and (e) ad hoc planning, overspending and poor quality.

Much of the ongoing debate on how to improve the construction sector considered in chapter 1 implicitly seem to assume that the characteristics of the sector is undesirable and to some degree unexplainable (besides that they are obsolete left behinds from ancient times). In contrast, this thesis suggests that the present way of organising the construction process solves many of the challenges created by rapid changes in overall demand. Without recognising these benefits, suggestions on how to improve the sector stands a little chance of being successful.

Yet, the (lacking) long term dynamics of the present organisation still make improvements of the sector desirable. How to do this is the topic of the epilogue that follows.

Chapter 10 - epilogue

A room for improvement

If anything, this thesis has substantiated the claim that the present organisation (including coordination) of construction at least in the short run is a way to minimise on costs related to production and coordination. Or to put it in less economic terms: that sound reasons for the present organisation of construction can be given. Without considering the positive sides of the present organisation, suggestions to a reorganisation of the sector do not stand a good chance of survival.

But although the thesis devotes more attention to understanding the present organisation of construction rather than to criticising it, the question still remains: is it possible to improve the organisation of construction and in what way?

The benefits of present organisational forms have to be understood in light of the need to adjust to fluctuations in overall demand. To recall, these external changes in general favour adaptability more than specialisation and as part of this, promote temporary working relations, isomorphism, the involvement of many small firms, and the separation of coordination and production.

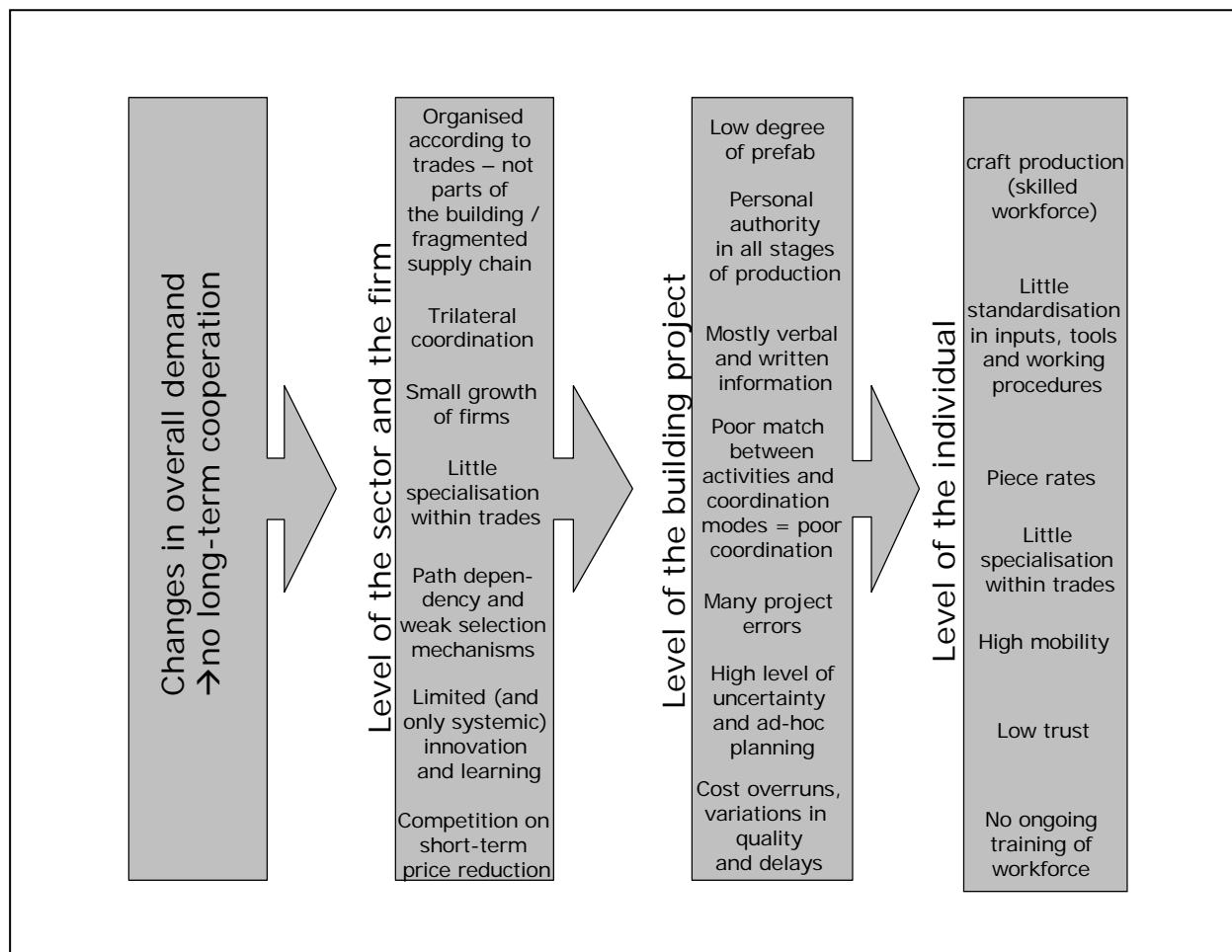
However, one should not be blind to the disadvantages of this system. In particular, this thesis has substantiated that the present organisation of the construction industry may economise on costs in the short term, but not in the long term.

For instance, through the trade system it becomes possible to obtain some of the benefits – e.g. lower coordination costs – from repetition, which cannot be reached at the firm and personal level due to demand fluctuations. However, some of the particular benefits from repetition – as for instance continuous improvements in production and coordination or more radical innovations of products or processes – are hard to obtain, as the whole idea of the trade system is to follow well-known paths. Correspondingly, selection mechanisms are weak in construction; because it is important to be “alike”, more efficient firms do not drive out the less efficient ones.

For the same reason it is very difficult for a single firm gradually to improve this system. Although other ways of organising the construction sector may be more efficient in the long run, it would not pay for a single actor to change to this “other” way of organising, unless other firms do the same. This makes it likely that construction is in a situation, where the in the long term unsound behaviour of a few dictates the behaviour of all.

Figure 1 shows a simplified view of the long-term structural impact of market fluctuations (and the associated temporary working relations) proposed in this thesis.

Figure 1: Structural impact of market fluctuations on the organisation of the construction process



If correct, this figure suggests that rather than treating many of the issues within the ongoing debate on how to organise construction (see chapter 1) as problems on their own, we have to see them as consequences of a

more fundamental problem. The issue of how to create trust is one example of this (discussed in chapter 8). “Industrialisation” of construction by means of building systems is another. Building systems is often perceived as a way of reducing uncertainty (Russel 1981). What is suggested here is the opposite: some degree of certainty (in particular with respect to long-term working relations) is a prerequisite for building systems (which then again can reduce uncertainty even further). A third example is the ongoing discussion (at least in Denmark and the UK) on how to improve the educational level and skills of the people working on the building site. No matter how appealing this idea seems, it is very hard to implement when the logic of the sector is not to invest in specialisation beyond the level of trades.

Following from this, the question of how long term relations can be established in an unstable setting becomes of outmost importance.

One possibility is to create some level of stability in overall demand. Large public investments may create “isles of stability” that - combined with a conscious focus on organisational behaviour - could bring about changes. This is at least one possible interpretation of how the prefabricated concrete building system - that is now the dominant way of building multi-unit housing in Denmark - was invented in the post war period. Besides encouraging a change by means of legislation and research, the Danish Government provided an isle of stability by launching four major building plans consisting of in total approx. 7000 flats (Bertelsen 1997 and Bang, Bonke, and Clausen 2001).

Yet, large building programmes initiated and financed by the government do not appear to be at the top of the political agenda today.

If that is indeed the case, this raises the question of who can initiate and direct concerted change. Here, Chandlers (1990) story on the rise of large vertically (this is integration of subsequent activities in a value chain) integrated corporations in United States in the late nineteenth century is thought provoking. In essence, his argument is that a combination of higher income and improved infrastructure paved the way for mass production. However, to bring about mass productions required simultaneous change in various parts of the value chain and this was facilitated by central ownership and control (Langlois 2001). It could be conjectured that the large construction firms, which have surfaced in

Denmark in recent years (e.g. MT Højgaard, NCC, Skanska) perhaps¹ could play this role.

This would be particularly effective, if these firms were able to locate (or through the use of their developer function *create*) segments of the markets that are less volatile than the construction market in general. The basic idea is that in a large construction firm it should be possible to promote “isles of stability in production” as there even in periods of recession will be some level of building assignments. Fundamentally, this idea is identical with Berger and Piores (1980) notion of a dual organisation in which one part of the company (or the market) works under stable conditions and consequently uses relatively specialised human and capital resources. The other part absorbs fluctuations by means of a less articulated division of labour and specialisation.²

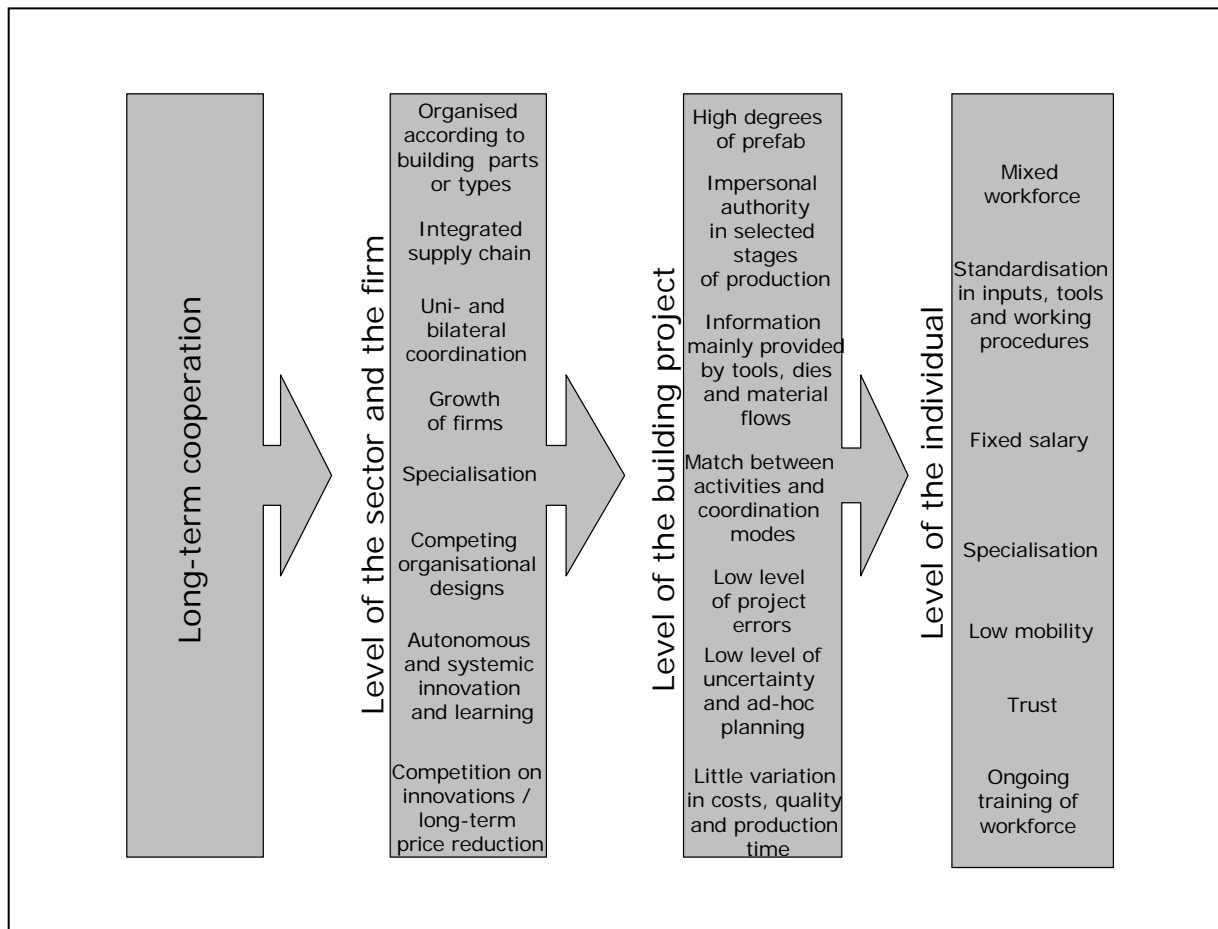
The idea of creating long term relations in the Danish construction sector have recently been encouraged by recent legislative changes that enable long-term framework agreements with specific client. Moreover, the National Agency of Enterprise and Housing has announced its support to the clustering of governmental building projects.

Basically, I argue in favour of what could be termed as a “demand shock” (Erhvervsfremme Styrelsen 2001), in which long-term relations are encouraged. According to the main argument of this thesis, this could in turn pave the way for a new organisation of the building process. By the end of the day, the result might be as depicted in figure 2.

¹ I stress “perhaps” because despite the fact that these large construction firms exist, and even though they have almost all functions in the value chain in-house, at present these different functions work rather independently.

² The fact that the idea is to *introduce* this kind of dualism in construction also suggests that dualism – in contrast with the general claim of Berger and Piore (1980) – is not necessarily very dominating in all sectors.

Figure 2: Hypothesis on the structural impact of reduced market fluctuations



New ways of demanding housing that allows (or even favours) long-term cooperation will reduce the danger of path-dependency, as multiple ways of organising the process can co-exists.

But at the same time, establishing long-term collaboration is itself subject to path-dependency. The companies and people working within the construction sector are in many ways perfectly adjusted to the present short-term cooperation, so even if they are placed in a less temporary setting, their behaviour do not necessarily change.

This has become very clear to me in the last 1½ year where I have been employed within MT Højgaard, among other things with the purpose of establishing long-term relations with selected sub-contractors as well as engineers and architects. For instance, if a producer of building components are promised a larger batch of production, the reduction in prices are not worth mentioning. At least partly, dies and ways of

calculating expenses geared towards small-scale production can explain this. Similarly, piece rates and ways of calculating costs at contracting firms are based on experience from one-off projects, so no one knows the right price if projects and collaboration are made continuous (in general the higher level of uncertainty probably implies that benefits from repetition is underestimated). The end-users are so used to products made according to what is possible to build on site by the trades, that it is difficult for them to accept truly new solutions. For instance, it is only acceptable to use prefabricated bathroom units if they look exactly as if they were build traditionally on site.

To illustrate, changing the way the sector collaborates probably corresponds to changing a traffic system from left-lane driving to right-lane driving (or conversely). Such a change is hardly likely to emerge by local initiative (the “premium” from being the first to change lane is not exactly attractive) – it has to be concerted.

It is remarkable that more fundamental changes within construction often coincide with a strong external pressure for change. The prefabricated concrete building system alluded to previously in this chapter would hardly have emerged in Denmark without a strong political pressure to (a) increase the supply of buildings and (b) reduce the bottlenecks of imported goods and skilled bricklayers (Bertelsen 1997). Similarly Bowley (1966, p. 83) observe with respect to the British building industry that

“...the Second World War provided the opportunity for the exploitation of some of the new techniques and knowledge that had been used so hesitantly, or not at all, in the interwar period”.

Bowley gives four reasons to “wartime innovations”: (a) greater risks are accepted, (b) initiatives are centrally coordinated, (c) the market for solutions are guaranteed and (d) costs are calculated differently. Reason b and c corresponds well to (and a and d are not inconsistent with) the framework proposed here. The impact of war (in UK) and of housing and inputs (in Denmark) is twofold. Firstly, it creates “isles of stability” in demand, and secondly it coordinates by central means the behaviour of the various people working along the (fragmented) value chain.

Perhaps all the various initiatives going on in and “around” the Danish Construction sector provide an external pressure strong enough to

ensure a shift to a path based on long-term collaboration. Perhaps, additional shocks are needed (for instance technological chock, chocks from firms and actors not presently working in the construction sector or regulatory shocks).

Irrespectively, a simultaneous change is needed in various part of the construction sector. Even though further reflections are needed in this area, let me conclude by pointing towards some of the actions that I believe rather immediately could and should be taken by key actors:

Government:

- By legislation and information, keep on promoting the idea of long-term framework agreements and clustering.
- Use long-term framework agreements for projects directly financed by the central government (“Statslige byggeopgaver”).
- Offer quotas for building of private rented houses³ in particular to clients who offer the largest long-term price reductions.

Local Government

- Provide the right to build social housing to clients on a long-term basis. Again, the ability to ensure long-term price reduction should be a major criterion for selection.
- Cluster own building activities with neighbouring municipalities and establish long-term agreements with integrated supply teams (including architect, engineer, general contractor and the major contractors).

Larger clients

- Use the possibility of forming long-term framework agreements; and as part of this establishes long-term relations with integrated supply teams.

Architects and engineers:

- Engage in integrated supply and production teams
- Focus on design of modules, that at one hand gives flexibility to the product and at the other hand ensures repetition in the design and production process.

³ Cf “lov om fremme af privat udlejningsbyggeri”

General contractors

- Establish a dual strategy and organisation in which one part of the firm is specialised in working in more permanent relations, and another part (as now) work in temporary relations.
- Segmentation of supplier relations (i.e. contractors as well as architects and engineers) according to the dual strategy, in particular establishing or participating in integrated supply teams.
- Establish Research and Development units, that can promote change and that can profit from the possibilities of innovation in products and processes. R&D units could be placed within the firm or externally and perhaps in cooperation with core members of integrated supply teams.

Contractors

- Choose which part of the dual market to be in.

Most likely, these ideas also have rather radical implications for the various institutions that provide important inputs to the construction sector, for instance the education system and producers and suppliers of building materials.

Furthermore, a limitation of these initial reflections is that they depart from the existing roles in construction. By the end of the day, we might see presently unknown types of roles and firms. And we might not see the roles and firms that we presently do know.

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Appendix A - Introduction to the building project: Project specific sources to non-repetitiveness and uncertainty - an introduction to the construction process

The aim of this appendix is twofold. First of all, an overall understanding of the main phases and actors of the building process would be beneficial in order to understand the details of the case study (on roof construction); in particular for readers without prior knowledge of the construction sector.¹ A second objective of this appendix is to illustrate some of the project specific sources to non-repetitiveness and uncertainty.

Partly, this appendix is based on observations from the case study - in which also the idea and planning phase was followed with participation in five project-planning meetings. However, as the idea of this appendix is to facilitate a wider understanding of the building process than the one relating directly to the research questions and roof construction, additional sources have also been used; for instance observations from site meetings on another project and personal experience as a client representative in a medium scale social housing organisation (see overview of data sources in chapter 4). Even though these different sources expand our view of the construction process, the reader should be aware that they all relate to the building activities. Hence, the following description will only to some degree capture civil engineering activities.²

1.1.1. Phases of the building process

The case study focuses on (some of the) activities and coordination during execution of the building process. However, as seen in the very stylised figure 1, building the roof is just one part out of many in the

¹ An alternative introduction to construction activities and contracting firms can be found in chapter 2 in Bang 2002.

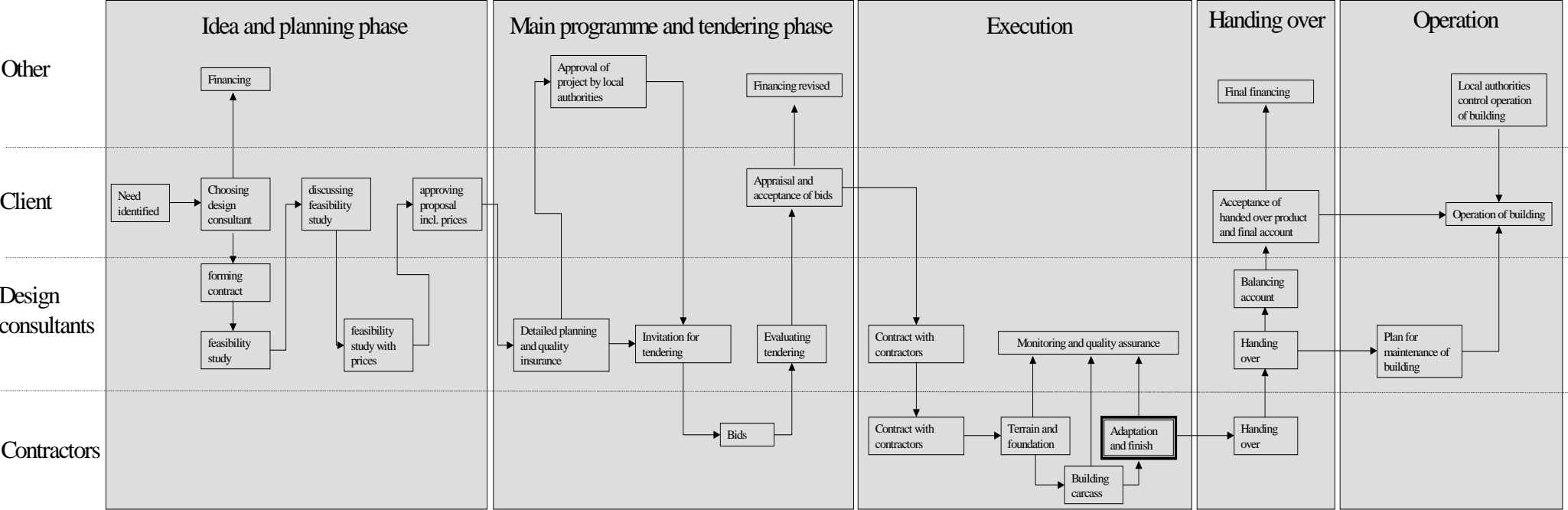
² Civil engineering activities concerns construction of physical infrastructure such as roads, bridges, ports etc

value chain providing housing facilities (roof production is part of the box emphasised with a double line).³

It should be noted that the size of each phase in the figure does not represent their respective duration. This obviously varies according to the size of the project. But even for cases of an identical size, say medium scale social housing projects, the time spent from the moment the first idea of a house emerges until the house is in operation, varies considerably. Especially the *idea and planning phase* varies a lot, since many conditions have to be sorted out prior to building the house, for instance feasibility studies, clearance from local authorities, and negotiations on price for plot. So this phase often takes years. Passing this first stage, the remaining phases are somewhat more stable. For a medium scale social housing project, *tendering* and *execution* takes approximately 12-18 months in total. However, the tendering phase can also be substantially prolonged in case the parties cannot come to an agreement concerning price. *Handing over* is ideally an activity that takes place within a few days but if error recovery is necessary, weeks and even months can be required. Especially if the parties cannot come to an agreement on the extent of, and possible extra payment for, the error recovery. The duration of *operation* obviously equals the life span of the building.

³ The figure is a conventionalised representation of the phases and actors involved in building a medium scale multiunit residential house. The aim of the figure is not to give an idea of all the complexities and backflows involved in construction, but rather to give a simplified view of this process as it is usually perceived by the people working in the sector (see also Thomassen 1998). I am grateful to Knud Bindeslev, an experienced engineer, who helped me producing the figure. It should be noticed that in the case study, as part of the PPB-programme, the tendering process was replaced with direct negotiation between the turnkey contractor and subcontractors.

Figure 1: A stylised representation of phases and actors in the value chain of house construction



This randomness of when a project is launched, inflicts disturbances on the level of production, and in turn on the level of employment, for the various firms involved in construction. This element of volatility is not considered in the analysis provided in chapter 5. If the impact of this randomness is assumed to be dependent on the size of the assignment compared with the size of the single firm (e.g. the resources of small firms will be highly affected if they get / do not get a large project), supposedly this impact is in general very high for (the small) construction firms compared with (the larger) manufacturing firms.

As it usually not known when, and if, a project will commence, it is difficult to commit resources to a particular project well in advance. Perhaps this explains why it apparently is common for firms within construction to have a big portfolio of projects *in spe*. In this interpretation, each project *in spe* is a kind of “lottery ticket” that occasionally is “drawn” (and subsequently built), which *on average* provides an even amount of orders. However, due to the “lumpiness” of construction projects (rather big assignments compared with the size of most firms), situations with excess or lack of orders are expected occasionally. As a way to reduce this effect, firms can pool together their orders, which - according to the carpenters and painter on the case study - is not an unusual practice in construction. Nevertheless, problems of this nature further stresses why flexibility rather than specialisation are of essence for construction firms.

1.1.2. Actors of the building process

Figure 1 also gives us a clue of the many actors that partake in the building process.

The client and client representative⁴

The client is the actor ordering the product. The client is responsible for paying for the building, which in practice often means being liable for the loan – provided by mortgage-credit institutions or banks - financing the building. In this way, he holds the residual rights to the building,

⁴ In Danish known as “Bygherren” and “bygherrerådgiver” respectively.

which are those rights that are not defined in contracts or by law.⁵ These rights contain an economic responsibility, for instance in case of loss of rental.

Consequently, it is in the interest of the client to specify the product according to the needs of the future users (who may, or may not, be him self). Sometimes, as in the case study, the client presents some overall ideas, and in dialogue with an external architect or contractor, a programme for the building is gradually developed. In other cases, as for instance in some of the major social housing, very dense manuals are made that describe the building very thoroughly, for instance which bricks to use for the cladding wall, types of floors, the exact type of refrigerator etc. In other cases, such as large industrial companies that build production facilities recurrently, the client has an in-house project development department. This department designs the building according to the needs for that particular building, which obviously gives less room for the external design team that, nevertheless, usually is employed.

However, the engagement of the client goes beyond the initial phase in the sense that he, to a varying degree, also takes part in the planning and production phase. In the planning phase the client ensures that the specifications set initially are met. Very often this includes elaborating and specifying the specifications further. The client ideally approves all major decisions in this phase and plays a less significant role in the production phase. However, a lot of planning goes on *ad hoc* during the production process, which enhances the role of the client even in this phase. In this way, the client is often enrolled in the (very technical) decisions on production.

The role of following the planning and production phase is either carried out internally by the client or externally by a client representative. Internal advisers are mainly used on very large projects or when the client builds repetitively. Clients who only build once or occasionally usually hire an external client representative. For instance, the client in the case study, a rather small social housing organisation that had not

⁵ In general terms, these rights include *use rights* (defining the use of the building), *income rights* (or right to use the building himself), rights to *exclude* non-owners, and rights to *sell* the plot and the building (K. Foss 2001b)

built for many years, hired a client representative from a larger social housing organisation.

Producers of building materials

This consists of a large group of very different kinds of firms performing a wide range of activities. However, they are all identical in the sense that they provide the materials used in the construction process.⁶

In this group, four different kinds of actors can be identified. *Producers of raw materials* extract the basic materials that building materials consist of. Producers of materials then transform these into semi-processed standard building products. Examples of such products could be bricks, mortar, standard wooden boards etc. These products are produced in large scale and to a wide range of customers. Occasionally, these standard products are cut into size and assembled by *producers of components*. So even though these prefabricated solutions are based on standard products, they are highly specific since they are usually made for a specific building project. With few exceptions, prefabricated components or building parts are made to order. Examples of such products are bath and toilet units, kitchen units, rafters and concrete panels. Finally, *dealers* take care of selling the products. This includes storage, informing about the different products, and occasionally also transportation from the producer to the building site. However, these activities are not always carried out by an independent actor, but can be internalised by the producers. Direct sale is particularly common for producers of components, which can be traced back to the specificity of these products.

Architects

Together with civil engineers, architects form the design team (in the following architects and engineers are referred to as “design consultants” or “the design team”). The design team is the cornerstone of the planning process, but also plays a vital role during production.

⁶ This appendix is far from an exhaustive description of the building materials sector. However, since the focus of this thesis is mainly on coordination practices during the process of construction, the rather divergent group of producers of building materials are treated under one heading.

An architect covers a lot of different activities during a construction project. At first, he transform the overall wishes of the client into a visual design of the building, suggesting the overall disposition of the plot, the exterior lay-out (shape and materials) and types and shape of rooms. In this activity, the architect uses his knowledge on shape, function, aesthetics, colours etc. Often a landscape architect is employed to design the areas that surround the buildings. Later on in the planning process, the architect adjusts the visual design to the more detailed desires of the client, as well as the requirements put forward by the civil engineer.

The design team has the overall responsibility for the planning process except when carried out as a design and build contract, in which the general contractor takes the responsibility. Thus, architects and engineers do not only have to provide services themselves, they also coordinate the contact with other parties, such as the client, local authorities and different kinds of technical experts.

During construction, the role of the design team is potentially two-fold. First, to carry out the ad hoc planning that becomes necessary due to unpredicted events. Secondly, in some organisational set-ups (i.e. *traditional contracts* as described below) it is the role of the design team to coordinate the activities of the contractors.

Civil Engineers

A main activity of this other half of the design team is to ensure that the building lasts. It is the job of the civil engineer to transform the drawings and models of the architect into a house that is capable of resisting the forces of nature. This activity of calculating the static includes a lot of computation. Adding to this, it is also the role of the civil engineer to ensure – as part of the quality control document – that the installations of the house (water, electricity, ventilation) have the right dimensions.

Secondly, the engineers – sometimes in collaboration with the architect – ensure the “buildability” of the house, that is they ensure that the different parts of the house fit together and can be built/completed by the (sub)contractors. This activity includes work-plans and technical drawings.

Finally, the civil engineers take part in the construction process as described above.

Where it is usually the same architect that takes care of all the different aspects of the planning phase, civil engineering can be divided among different firms. Some civil engineering firms have specialised solely in for instance making calculations concerning ventilation, leaving the overall coordination issues to other civil engineers.

*General contractors and project management*⁷

As the name indicates, general contractors are not specialised in any particular trade, but take on a more superior position. The exact way in which this is done depends on the contractual scheme. In a traditional contract there are no general contractors – the client representative contracts directly with the different trades. In main contracts, the general contractor usually carries out the activities of one of the trades himself (usually some of the bigger trades, like concrete or carpentry).⁸ Furthermore, the general contractor is responsible for the work performed by the firms to which the remainder of tasks are subcontracted. In design and build contracts the role of the general contractors is even bigger, since the design team now contracts with him and not the client (the client only contracts with the general contractor). Hence, in this set-up the contractor is (a superior) part of the design “team”.

The general contractor conducts the *project management* except in traditional contracts, where a firm (often an architect) contracting directly with the client performs this job.

Project management is usually located on the building site during the entire phase of execution. With respect to interfirm coordination, an important role of project management is to ensure that timetables are met. This is done by providing timetables and by monitoring the progresses made by the contractors. The latter issue constitutes an

⁷ In Danish general contractors are known as “hovedentreprenør” and in turnkey or design and build contracts, as “totalentreprenør”; project management as “byggeledelse” (working during the execution phase).

⁸ Occasionally, the general contractor carries out the job of multiple trades on a single project. However, this is rare, and usually does only come about if each of the firm’s respective departments wins a tender. Hence, general contractors do not internalise building activities – and coordination hereof - in any systematic and recurrent way.

important part of the agenda at the weekly site meeting chaired by project management and with representatives from the respective trades working on site (see box 1). The site meeting can also be used in order to solve disagreement between contractors. For example, project management can come up with solutions that are acceptable to all parties or clarify who is responsible according to the contract. Secondly, project management also monitors that activities are carried out as prescribed by the design team. In particular, this is done by reinforcing the quality insurance system. As part of this, project management considers the reasons for technical deviations or delays and based on this, they assess whether extra payments or extensions can be approved. Project management also approves deviations from these prescriptions. Occasionally, the design team is contacted prior to approval, and conversely, the design team uses the project management as a transmitter of information to the subcontractors. For instance, subcontractors get in touch with the project management in order to find out if any revisions of drawings or technical specifications have been made. Similarly, project management provides information to subcontractors, public suppliers and other actors of the building process about where they can find other firms or persons working on the site.

Box 1: The weekly site meeting¹

At almost every building project in Denmark, a weekly site meeting (*byggemøde* in Danish) with representatives from the major contractors is held. This site meeting is chaired by the project management. The institutionalisation of the site meeting is seen in the fact that it is mandatory according to AB92 (roughly translated to *General Conditions of 1992*). AB92 (or ABT93 for turn-key projects) is compulsory to use for all publicly or public supported building projects, but is also frequently used for building projects with private clients.

The agenda for a site meeting is more or less the same from one building site to another and can include the following topics:

- 1) comments to the minutes from account for last week,
- 2) manpower and equipment used at site for the different trades,
- 3) number of wasted days,
- 4) deviations from timetable,
- 5) percentage of work completed by each trade,
- 6) conditions on the building site,
- 7) comments to the performed work,
- 8) quality insurance,
- 9) economy, and
- 10) any other business.

The minutes from the site meetings are important, as decisions made here are legally binding. For instance, if a specific solution is allowed by the project management and reported in the minutes from the site meeting, this replaces the contract originally written between the client and the contractor. Due to the legal character of site meetings, the minutes only reflect certain parts of the building project. During a case study conducted in the beginning of the PhD.-programme, it was often observed, how issues were informally discussed before or after the site meeting, or that the parties decided not to include a discussion at the site meeting in the minutes.

(Continues)

Box 1: The weekly site meeting. Continued.

If nothing is added at Ad 1 in the agenda, the minutes from the last meeting are approved. Ad 2 clarifies how many men and how much machinery (not hand-tools) that have been allocated to the site during the last week. Ad 3 concerns how many days have been wasted by the contractors, due to, for instance, changes made by the client, delays by other contractors, or the weather (in these cases the contractor can claim extension of the deadline according to AB92). Ad 4 is used for discussing deviations from the timetable in the week that follows. Ad 5 summarises (in percentage) how much of the different activities of each firm have been completed. Ad 6 relates to the conditions of the building site, for instance, if some firms are blocking the access-roads, or if there in wintertime are problems with the outdoor lighting. Ad 7 is used for discussing or informing about deviations or clarifications of technical descriptions. Ad 8 reports if the required quality insurance documents have been provided. Ad 9 is used for discussing and perhaps approving the claims for extra payment made by the subcontractors.

*Subcontractors*⁹

Subcontractors, or simply contractors, are the actors who actually build the house. Contractors represent different trades: bricklaying, carpentry, plumbing, electricity, painting, concrete labouring and gardening.

Traditionally, different trades correspond to different materials: the bricklayer takes care of tile-products (bricks and tiles for, say, bathrooms); the carpenter mainly makes large and simple wood constructions and other constructions in semi-soft materials (e.g. eternite plates), but also performs more delicate woodwork; the plumber works with metal; the painter with painting; and finally, the gardener works with soil and plants.¹⁰ Even though observations in the case study suggest that this description still is fairly correct, the picture is not static. First of all, as new building materials are introduced, the trades expand

⁹ "Underentreprenør" in Danish. These contractors are subordinates either to a main contractor or a turnkey contractor. In case of a traditional contractual scheme (one without main contractors or turnkey contractors), they are simply called contractors ("entreprenør").

¹⁰ Terminologically, there is a rather direct relation with the name of the trade and the work they do. A "tømmer" (carpenter) works with "tømmer" (wood), a "murer" (bricklayer) works with "mursten" (bricks), a "maler" (painter) works with "maling" (painting) etc.

their activities into new areas. According to the carpenters in the case study, separation walls in plaster have been added to the list of materials processed by carpenters. Furthermore, in addition to these ancient trades, a few “newer” trades have emerged as a response to the technical development, for instance electricians or the concrete labourer (the latter as a response to the development of concrete panels).

Within each trade, further specialization takes place occasionally. For instance, some carpenters only make kitchens, whereas others specialise in floors, wooden structures etc. However, these kinds of specialised firms were not observed in the case study, and a case study on a small refurbishment project in Odense (Bertelsen 1996, 2002) seems to support the view that, at least within refurbishment, they are not dominating.

A *foreman* is usually appointed for each trade working on the building site. The foreman can have various obligations, for instance (a) allocation of activities within the group of people employed in the trade, (b) form a communication link between the craftsmen on the one hand and superior levels (e.g. project management or the management of the firm) on the other hand, and (c) participating in the ongoing planning conducted on the site.

Within the firm, the foreman is usually subordinate to a *clerk of work*¹¹ in larger firms or to a master¹² (the owner) in smaller firms. The clerk of work (or master) can share some of the obligations of the foreman (as it was the case in the carpentry firm studied in roof construction), but an additional and very important role is to allocate employees between different building projects. Thus, unlike the foreman, the clerk of work is usually connected to multiple building projects at the same time.

Local authorities

Even though the aforementioned actors do often not consider local authorities a part of the project organisation, they have a big say in the process of building. For social housing two elements constitutes this role. First of all, the local authorities has to – as for all kinds of construction projects – approve that the building process as well as the final product

¹¹ “Konduktør” in Danish.

¹² “Mester” in Danish.

fulfil the present legislation at the EEC, the national, and the local level. The latter includes zoning laws, which sometimes are very specific with respect to the design of the building. Due to especially the zoning laws, local authorities quite frequently interfere in the planning as well as in the production phase.

Secondly, for social housing, the local authorities administer and partly finance the governmental support. In order to give this support, the client has to provide different kind of documentation and fill out application forms. This interaction mainly takes place in the planning phase.

Technical assistance

Different kinds of technical assistance can be included in planning and production. With very few exceptions, a *land surveyor* is used in order to estimate the exact size of the plot and – which is very important for the subsequent production – to map contour lines. A soil analyst can also be included in order to estimate laying foundations and potential pollution. If the latter is observed, the soil analyst will have to estimate the extent of the pollution and what to do in order to fulfil governmental requirements. *Sound technicians* are a third example of external technical assistance used for a specific and delimited purpose.

The three parties mentioned here will often carry out their activities early in the process, that is prior to or in the beginning of the production phase.

Public supply

This covers the supply of electricity, water, sewage and eventually heating. Different firms provide all these services that may be termed under the heading “public supply”. The role of these companies is to promote the connection to the general net for the respective services. As part of this, these companies inform about the capacity and exact terms of connection.

Apart from providing this main supply, they have nothing to do with the further distribution in the building; this is taken care of by the contractors.

Allowances for existing main installations also necessitate a close interplay with public suppliers during the idea and planning phase.

Neighbours

As part of the Danish system of district plans, neighbours can raise objections to the proposed design and / or use of a building. This can seriously change or prolong the idea and planning phase. During construction, neighbours can affect the process by insisting that especially noise levels are not violated.

In dense areas, new buildings often adjoin neighbouring houses. In these cases the neighbours have to approve the union. As seen in the case study, this process can become even more complicated, if the new building imposes an exchange of real property. Ideally, this interaction takes place in the initial phases of the planning period. In reality however, negotiations are not always closed before the building project is well under way. Obviously, this inflicts elements of uncertainty on the project.

Appendix B - An “information-structure” interpretation of costs of coordinating non-repeated and complex activities with many actors

1.1 Introduction

In chapter 3, the costs of handling information by different coordination modes were discussed. In particular, contributions reflecting on the costs of handling coordination when many actors were involved in temporary and complex activities were consulted. In this appendix I take this discussion one step further by following up on the idea (forwarded in section 3.1.4) that the different coordination modes can be perceived as different types of networks / information-structures. Further, with reference to the discussion in chapter three, I will propose different information costs that all structures cope with, but not in equally efficient ways.

Thus, the overall objective of this appendix is to illustrate, how an information-structure approach contributes to a systematic understanding of information costs of different coordination modes. In time, this may pave the way for a more *formalised* body of literature, and consequently this appendix is inspired by the works of e.g. Marschak and Radner (1972) and Balton and Dewatripont (1994). However, where their arguments are based on general mathematical reasoning (proof), I use analytical concepts provided by *social network analysis* to show, how information-structures handle information differently.

The appendix is organised as follows. Firstly different types of information costs are pinned out. Secondly, a “translation” of coordination modes into information-structures is proposed. Then it is outlined how the costs of these structures can be analysed by concepts from social network analysis. Finally, results are given and the use of information-structures / coordination modes in situations that vary with respect to the number of people involved, complexity and repetitiveness is briefly discussed.

1.2 Information costs

The first step is to identify different kinds of information costs in information-structures. As part of the costs of *using*¹ different structures, I propose the three following possibilities:

Costs associated with *the number of information connections*. The assumption is, that every act of sending off, transmitting and absorbing information includes costs: “an efficient network minimizes the number of communication channels between agents” (Balton and Dewatripont 1994, p. 822). Thus, other things being equal, the more links there are in a structure, the higher information costs.

Costs associated with *concentrated information collection and processing*. Assuming that each individual has a limited capacity to handle information (Arrow 1974), communication costs are raised when concentrated in single nodes rather than dispersed equally among nodes. These costs can be directly related to more than proportional time and mental resources spent on processing information or can be indirect as if for instance, relevant information is not considered (K. Foss 2001). Hence, other things being equal, the more the structure relies on specific transitional actors (that is actors transferring information between actors that are not in direct contact with each other), the higher the information costs.

Costs associated with *a large span of control*. If information has to move through many actors (i.e. a large span of control), it can result in slow and out-dated decisions. The basic assumption is that the decision of each actor takes time and that, other things being equal, prompt decisions are better than slow decisions. Secondly due to knowledge of the detail of the problem (Robinson 1934, Hayek 1945) or due to noise (Marschak and Radner 1972) a superior may not capture all details off the information provided by subordinates (or visa versa). Hence, other things being equal, “an efficient network minimizes the number of agents through which a given item transits” (Balton and Dewatripont 1994, p. 822).

¹ Note that costs of creating and identifying coordination modes for matters of simplicity are not considered here, except in the final discussion towards the end of the appendix.

1.3 Coordination modes as information-structures

The second step of this exercise is to translate coordination modes into information-structures. In agreement with Grandori's visualisation of information-structures (see section 3.1.4), I will propose the following simplification (some might say "caricature"):

- Price (and voting) represents a *partially connected hob-and-spoke structure*; it is a structure in which communication between all actors is mediated by a single central node (for instance an auctioneer).
- Authority, and to some degree agency, represents a *partially and centralised connected structure*; that is a structure where communications between sub-ordinate nodes are mediated by a superior node. If the number of sub-ordinate nodes involved exceeds a certain amount, more superior nodes are involved hence creating multiple layers of subordinate-superior relations (i.e. the structure is hierarchical).
- Teaming (and negotiation) represents a *totally connected and decentralised structure*, that is a structure where all nodes interact directly with each other without use of mediating nodes.
- Norms and rules represent an *unconnected structure*; that is a structure in which the actions of each node are not associated with any act of communication with other nodes.

Examples of the three first different information-structures are shown in figure 1-3. Each number represents an actor (or a node) and each connection represents exchange of information (which can go both ways and thus is illustrated with a double arrow (yet in the calculations that follow in section 4.5, communication is considered as undirected)).

Figure 1 : A 7-actor pricing communication structure

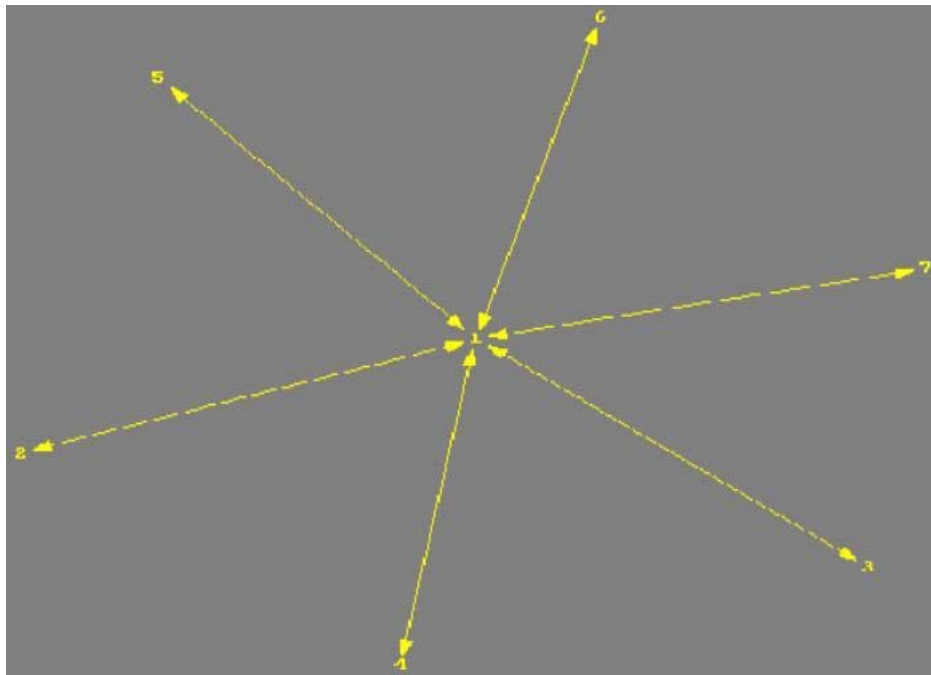


Figure 2: A 7-actor authority communication structure

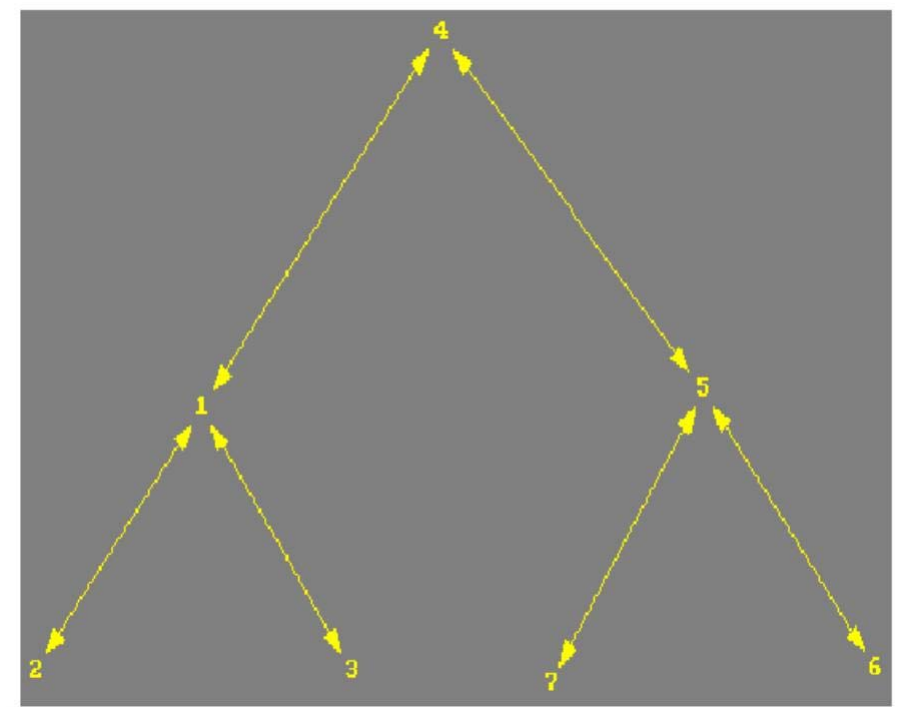
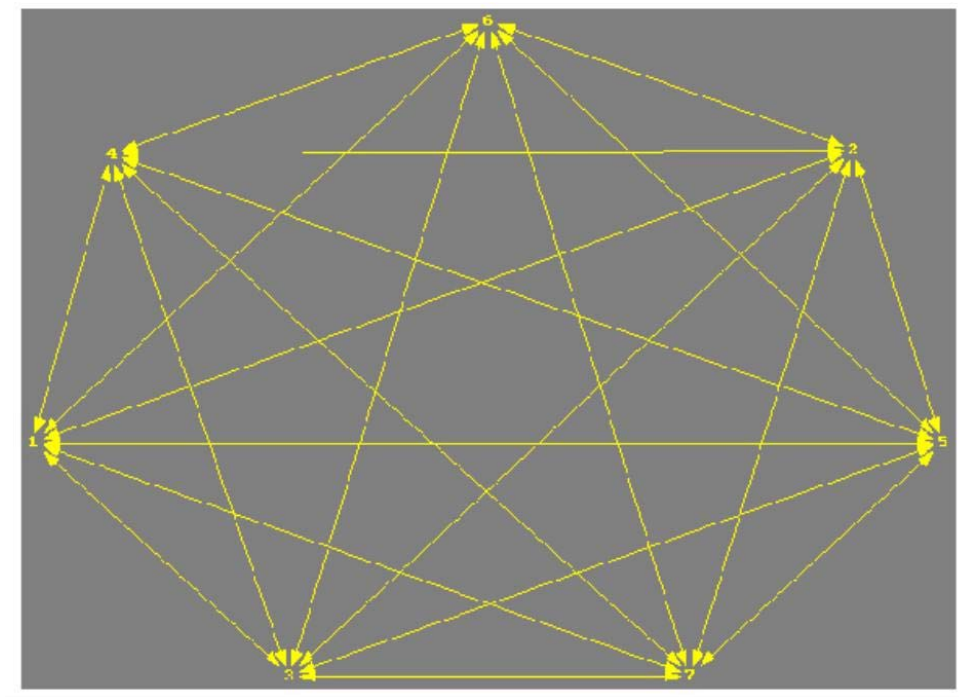


Figure 3: A 7-actor teaming communication structure



As *norms and rules* is an unconnected structure (there is no relational data) there is no visual representation of this structure. And for the same reason, no calculations are made for it in the sections that follow.

Authority is here conceived of as a system in which each superior has exactly two subordinates (and one subordinate has one, and only one, superior). Of course this is a somewhat arbitrary choice as the superior could have less (=1) or more (3 and upwards) subordinates. The results on *centralised information possessing* and *span of control* are affected by this choice (the more subordinates to a superior, the less increase in the span of control and the less increase in centralised information processing).²

For matters of simplicity I have only considered authority structures where the number of actors fits to the rule of one superior to two

² In order to investigate the impact of number of subordinates, an authority structure with 3 subordinates per superior was compared with an authority structure with 2 subordinates with approximately the same number of actors involved (121 and 127 actors respectively). *Distance* was 6,16 for the triple-structure and 8,35 for the double-structure. With respect to *betweenness*, the identical figures are 310 and 463 for the mean and 4800 and 4929 for the maximum value

subordinates. Thus the smallest authority structure consists of 3 actors, the next of $(2 \times 3 + 1 =) 7$, the next of $(2 \times 7 + 1 =) 15$ and so on.

1.4 Application of social network concepts to information costs

The cost associated with *the number of information connections* relates to how many relations that have to be activated in order to transmit an information to all parts of the structure. Thus, the *total number of relations* in the structure represents a simple proxy for this cost. With 7 actors this number amounts to 6, 6, and 21 for prices, authority and teaming respectively (see figures 1-3).

Costs associated with *concentrated information collection and processing* concerns the information load put on nodes connecting other nodes. The (Freeman) *betweenness centrality* measure is proposed as a proxy for this cost. This measurement counts the number of paths connecting (not directly connected) nodes that go through a node. For instance, the value for actor 1 in the 7-actor authority structure (see figure 2) is 9 (actor 2 can connect to 5 other nodes through actor 1 and as the network is not counted with direction, actor 3 can connect to 4 actors through actor 1).

The span of control has been measured by the *distance* function in Ucinet (with the type as data set as *costs/distances*). This algorithm finds the number of relations in the shortest path between each pair of nodes. For instance, the value for an authority structure with 7 persons as displayed in figure 2 is 2,3 meaning that in order to connect one actor to another actor in average 2,3 actors have to be passed through.

A basic assumption when using the two latter measures is that any actor can have information that he wants to send to any other actor.³ Of course this is a simplification; for instance, the hub in the price information-structure may be an auctioneer that is specialised in transmitting information of others but who does not himself come up with any information. In case such inter-mediating specialists in coordination exist, this will on one hand increase the costs of using information-

³ This is identical to Hart and Moores assumption (1999), that any individual in a hierarchy can come up with an idea. Unlike Hart and Moore, however, I do not assume that, information or ideas in certain parts of the structure (for instance higher hierarchical layers) exclude or have precedence to information in other parts of the structure.

structures as the distance and concentration grows. On the other hand, costs per information bit are properly decreased due to specialisation.

1.5 Results on the efficient use of coordination modes

Now, having identified different types of costs, let us see briefly reconsider the costs of handling the three informational contingencies (variability, complexity, and number of actors) by different coordination modes / information-structures.

With respect to the first kind of costs, the *number of connections* does not vary much for the different information-structures for very small groups. However, as size increases, the total connected structure (teaming) becomes very heavy to operate (Table 1).

Table 1: Size and the total number of communication links

Number of actors	Prices	Authority	Teaming
3	2	2	3
7	6	6	21
15	14	14	105
31	30	30	465
63	62	62	1953
127	126	126	8001

Authority, as an only partially connected structure, is better at handling larger groups with respect to number of connections. On the other hand, it may create costs due to concentrated collection and processing of information (table 2).

Table 2: Size and “average betweenness” and “max betweenness”

Number of actors	Prices			Authority			Teaming		
	Mean	Max.	Centralisation	Mean	Max.	Centralisation	Mean	Max.	Centralisation
3	0,33	1	100%	0,33	1	1	0	0	0%
7	2,14	15	100%	3,86	9	40%	0	0	0%
15	6,1	91	100%	17,53	57	46,47%	0	0	0%
31	14	435	100%	59,33	273	50,76%	0	0	0%
63	30	1891	100%	173,19	1185	54,37%	0	0	0%
127	62	7875	100%	463	4929	57,16%	0	0	0%

As seen, measured by the average, authority is the structure that suffers the most from increased size. The betweenness values are increased towards higher hierarchical layers and are for networks at a certain size largest at the level second to the top.⁴ As these figures illustrate, grouping activities with high interdependencies in the same part of the structure (i.e. placing them under the same superior at the lowest possible level), can be an essential part of an effectively designed authority structure. Thus, without knowledge of interdependencies (for instance due to low repetitiveness), it can be costly to handle information by this structure.

Since each central node (superior) can only handle coordination for a limited number of decentralised nodes (subordinates), more levels have to be introduced as the number of people involved in coordination expands. For very large groups this can increase costs associated with a large span of control.

⁴ In a 7 actor authority structure with 2 subordinates per superior, the betweenness values for the “zero” level (i.e. the lowest level) is 0, for the first level it is 9 and for the top level it is 9 as well. If this structure is expanded to comprise 15 actors, the values are 0, 25, 57, and 49 for the zero to the third level, respectively.

Table 3: Size and average distance

Number of actors	Prices	Authority	Teaming
3	1,33	1,33	1
7	1,71	2,29	1
15	1,87	3,51	1
31	1,94	4,96	1
63	1,97	6,59	1
127	1,98	8,35	1

Unsurprisingly, the average distance in a teaming communication structure is always 1 as all actors by definition are directly related. The average distance in pricing communication structure is approaching 2, as the importance of the hub-actor (the only actor with a value different (=1) than 2) decreases with increasing numbers of actors. In the authority structure, however, distance grows increasingly with size and is even for small structures greater than in pricing or teaming. Even though the increase soars less, if each superior can handle more than two subordinates (e.g. in a triple authority structure with 121 actors, the average distance is at approximately the same level as the double authority structure with 63 actors), the conclusion is not fundamentally different.

A way to reduce the problem of a big span of control is by introducing a hob-and-spoke structure as in pricing. However, the potential information overload of the central node in this structure can be extreme. This relates to a second aspect of costs of concentration processing of information displayed, but not yet discussed, in table 2. To recall, due to limited capacity of actors to handle information, costs are expected to increase more than proportionally when concentrated on a few individuals. Thus, it is not only the average betweenness but also the degree to which the betweenness is concentrated in a few persons (as measured by the centralisation index) that is of essence. In this respect, pricing is more exposed to increased size, as all information is located at a single person (the hub). Hence, in order for pricing to be efficient,

assumedly information has to be codified (or at least easily transferred and understood). An alternative is to make a disconnected structure (as in norms and rules). Yet, if this system is to be effective, some guidelines for behaviour have to be disseminated among the involved parties.

In balance, these reflections show, how the number of people involved affects the information costs of using alternative information-structures. Teaming is very efficient with respect to costs associated with concentration and span of control, but is costly to use with respect to the number of communication links. And as the latter grows dramatically with increased size, teaming seems most appropriate for small groups. The number of communication links expands less with group size in authority and pricing. On the other hand, authority faces problems with larger groups due to high average costs of concentration and, in particular, an increasing span of control. Pricing is in most respects capable of handling information in large groups at low costs, except for the information transfer and processing concentrated at the central node (the hub).

As the latter illustrates, there is a trade-off between costs of using and *creating* coordination modes. If pricing is to be effective, information has to be of a format in which it is easily handled by a single central actor; thus the need of codifying information in prices. Correspondingly, an efficient authority structure will to a large degree depend on being organised in a way, by which activities with high interdependencies are grouped together.

Partly due to a presumably different composition of creating and using costs, and partly due to using costs on its own, the alternative coordination modes are also differentiated with respect to the second contingency considered: *variability in activities*. With low variability (i.e. with high degree of repetition) the initial costs involved in coding of information is reasonable to bear in order to gain lower variable costs. Accordingly, if repetition is high, it makes sense either to invest in the provision and dissemination of formal rules, for instance working procedures, or to accumulate and rely on past experience laid down in social norms. However, if high activity variability creates less repetition, the cost of using pricing or norms or rules is higher either due to high fixed costs, or due to actions, that are not well fitted to the new situation. Particularly the non-calculative element of norms and rules creates a risk

of an “institutional gap” arising from a prescription originated in conditions that are no longer the same.

The *complexity of the activity* has been the last contingency considered. For very simple activities, only a few conditions have to be taken into account before they can be carried out. This enhances the possibility that a single central node can handle the information involved in connecting the activities of all other nodes; hence pricing and voting can handle activities with low levels of complexity. However, as activities become more complex, it is favourable to use less centralised information-structures. For less simple, but not very complex activities, authority can be used. However, for coordination of very complex activities, the information and knowledge, which the superior actor has to master, is beyond the cognitive restraints of a single person. Here, direct information without any mediating nodes, like in teaming, is preferable. Yet, there may be situations of such extreme complexity, that the information involved in coordination exceeds the capacity of even decentralised structures. Here, the only option is to use a non-connected structure; that is to abandon the deliberate act of coordinating as it is done by norms and rules.⁵

⁵ Or as in “rationing” suggested by Thompson (1967).

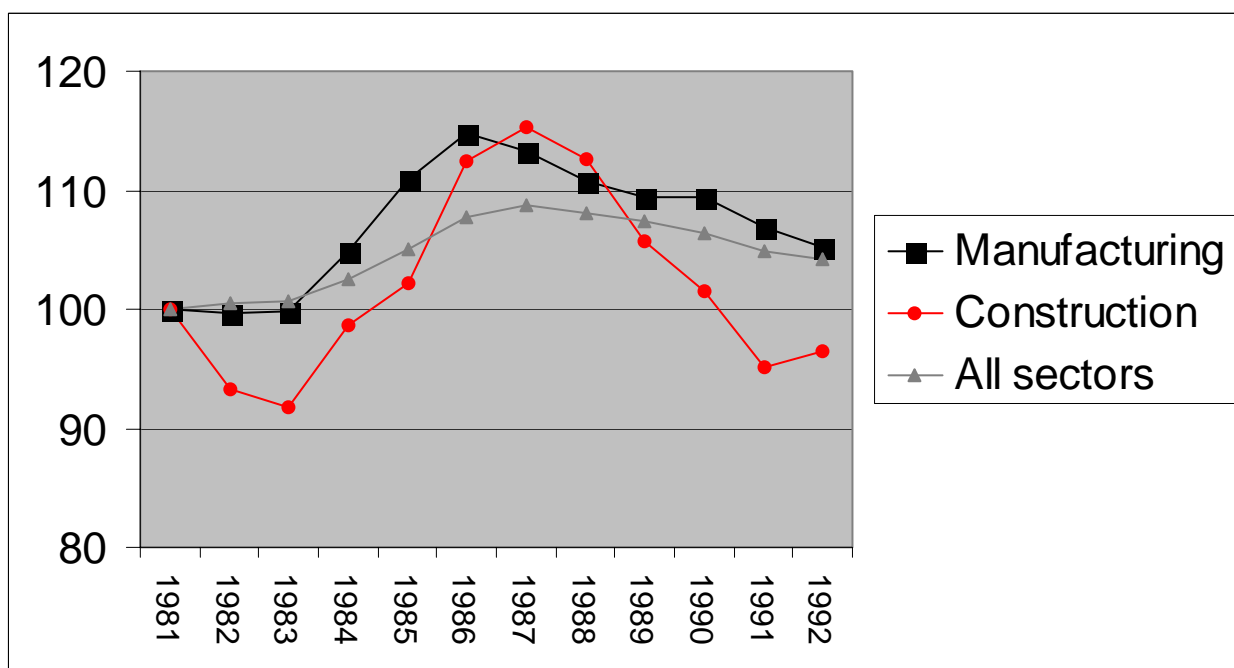
Appendix C – Supplementary statistical data

4.1. Introduction

This appendix provides additional statistical information to chapter four. Hence the appendix is hardly readable in its own but should only be used in combination with chapter 5.

4.2. Figures and tables

Figure 1: Employment in all sectors 1981-92 (1981=100)



Source: Statistical ten-year review 1990 and 1997.

**Table 1: Education of employers and employees in manufacturing (%)
- 1998**

	Manufacturing	Construction: Contracting firms	All sectors
Public school	35,88	30,59	27,91
High School	5,78	2,71	9,38
Basic Vocational Courses	42,18	55,8	37,8
Supplementary Vocational Courses	5,51	4,93	4,64
Diploma	5,42	3,86	12,23
Bachelor	0,76	0,16	1,02
Master	2,54	0,62	5,38
Doctoral / Ph.D. degree	0,15	0	0,21
Not known	1,79	1,32	1,43
Total	100	100	100

IDA-database. Own inquiries 2001.

Table 2: Geographical distribution of manufacturing firms, construction firms and firms of architects and engineers.

County	Manufacturing	Construction	Architects and Engineers
København og Frederiksberg Kommune	7,4%	5,9%	14,9%
Københavns Amt	10,1%	10,5%	13,3%
Frederiksborg Amt	6,2%	7,4%	9,5%
Roskilde Amt	3,9%	5,2%	3,7%
Vestsjællands Amt	4,7%	6,6%	5,1%
Storstrøms Amt	4,2%	5,4%	2,7%
Bornholms Amt	4,0%	3,7%	2,1%
Fyns Amt	6,0%	6,0%	5,2%
Sønderjyllands Amt	4,6%	5,2%	3,5%
Ribe Amt	4,9%	5,1%	3,6%
Vejle Amt	8,3%	6,8%	6,8%
Ringkøbing Amt	7,5%	5,6%	3,6%
Århus Amt	13,0%	11,2%	13,7%
Viborg Amt	5,6%	5,5%	3,2%
Nordjyllands Amt	9,5%	9,9%	8,2%
Other (foreign countries included)	0,1%	0,1%	0,8%
Total	100,0%	100,0%	100,0%
Number of firms	17133	17155	2309

IDA-database. Own inquiries 2001.

Where the geographical distribution of construction firms is close to the distribution of manufacturing firms, firms of architects and engineers are mainly based in the counties with, or close to, the major cities of Copenhagen and Århus.¹

¹ A more fine grained analytical level than "amter", for instance "kommuner", would probably show

Table 3: Survival of construction and manufacturing firms 1981-97 according to size (no. of men year in 1981)

0-4 Employees	Construction firms			Manufacturing firms		
	In Business	%Survived	% change from prev. year	In Business	%Survived	% change from prev. year
Start 1981	15904	100,0%		12350	100,0%	
End 1981	12487	78,5%	-21,5%	9862	79,9%	-20,1%
1982	10578	66,5%	-15,3%	8487	68,7%	-13,9%
1983	9531	59,9%	-9,9%	7598	61,5%	-10,5%
1984	8628	54,3%	-9,5%	6875	55,7%	-9,5%
1985	7952	50,0%	-7,8%	6257	50,7%	-9,0%
1986	7404	46,6%	-6,9%	5785	46,8%	-7,5%
1987	6885	43,3%	-7,0%	5277	42,7%	-8,8%
1988	6344	39,9%	-7,9%	4859	39,3%	-7,9%
1989	5847	36,8%	-7,8%	4464	36,1%	-8,1%
1990	5347	33,6%	-8,6%	4092	33,1%	-8,3%
1991	4948	31,1%	-7,5%	3787	30,7%	-7,5%
1992	4570	28,7%	-7,6%	3501	28,3%	-7,6%
1993	4250	26,7%	-7,0%	3271	26,5%	-6,6%
1994	4015	25,2%	-5,5%	3013	24,4%	-7,9%
1995	3812	24,0%	-5,1%	2828	22,9%	-6,1%
1996	3640	22,9%	-4,5%	2663	21,6%	-5,8%
1997	3489	21,9%	-4,1%	2513	20,3%	-5,6%

that also in other parts of the country, the firms of architects and engineers will cluster more than contractors.

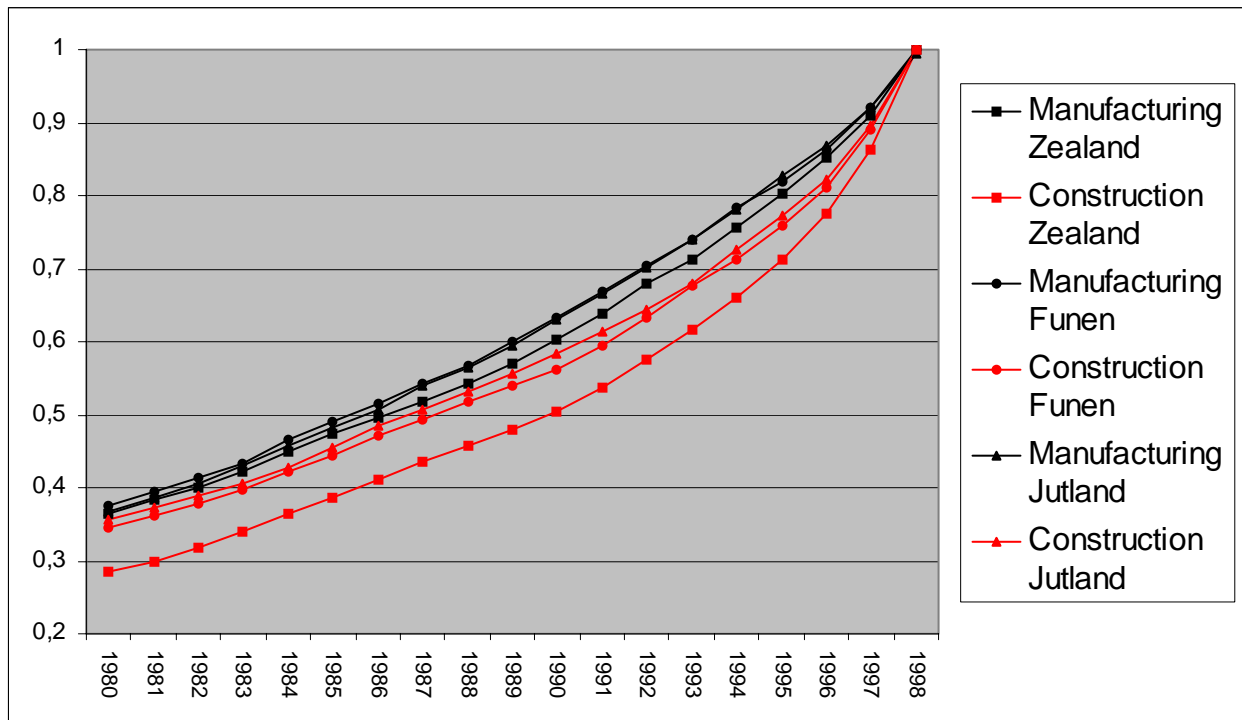
5-24 Employees	Construction firms			Manufacturing firms		
	In Business	%Survived	% change from prev. year	In Business	%Survived	% change from prev. year
Start 1981	4749	100,0%		6876	100,0%	
End 1981	4549	95,8%	-4,2%	6565	95,5%	-4,5%
1982	4276	90,0%	-6,0%	6108	88,8%	-7,0%
1983	4057	85,4%	-5,1%	5766	83,9%	-5,6%
1984	3888	81,9%	-4,2%	5491	79,9%	-4,8%
1985	3749	78,9%	-3,6%	5221	75,9%	-4,9%
1986	3603	75,9%	-3,9%	5000	72,7%	-4,2%
1987	3481	73,3%	-3,4%	4746	69,0%	-5,1%
1988	3359	70,7%	-3,5%	4555	66,2%	-4,0%
1989	3206	67,5%	-4,6%	4286	62,3%	-5,9%
1990	3042	64,1%	-5,1%	4079	59,3%	-4,8%
1991	2884	60,7%	-5,2%	3862	56,2%	-5,3%
1992	2757	58,1%	-4,4%	3648	53,1%	-5,5%
1993	2636	55,5%	-4,4%	3466	50,4%	-5,0%
1994	2535	53,4%	-3,8%	3270	47,6%	-5,7%
1995	2440	51,4%	-3,7%	3142	45,7%	-3,9%
1996	2359	49,7%	-3,3%	3024	44,0%	-3,8%
1997	2278	48,0%	-3,4%	2896	42,1%	-4,2%

25+ Employees	Construction firms			Manufacturing firms		
	In Business	%Survived	% change from prev. year	In Business	%Survived	% change from prev. year
Start 1981	630	100,0%		2658	100,0%	
End 1981	613	97,3%	-2,7%	2585	97,3%	-2,7%
1982	574	91,1%	-6,4%	2485	93,5%	-3,9%
1983	537	85,2%	-6,4%	2396	90,1%	-3,6%
1984	517	82,1%	-3,7%	2322	87,4%	-3,1%
1985	497	78,9%	-3,9%	2251	84,7%	-3,1%
1986	485	77,0%	-2,4%	2162	81,3%	-4,0%
1987	467	74,1%	-3,7%	2048	77,1%	-5,3%
1988	438	69,5%	-6,2%	1970	74,1%	-3,8%
1989	415	65,9%	-5,3%	1872	70,4%	-5,0%
1990	397	63,0%	-4,3%	1755	66,0%	-6,3%
1991	374	59,4%	-5,8%	1662	62,5%	-5,3%
1992	348	55,2%	-7,0%	1586	59,7%	-4,6%
1993	324	51,4%	-6,9%	1513	56,9%	-4,6%
1994	311	49,4%	-4,0%	1446	54,4%	-4,4%
1995	303	48,1%	-2,6%	1414	53,2%	-2,2%
1996	291	46,2%	-4,0%	1368	51,5%	-3,3%
1997	285	45,2%	-2,1%	1320	49,7%	-3,5%

IDA-database. Own inquiries 2001.

A Mantel-Haenzel test gives the following values. For 0-4 employees the difference is insignificant ($p=0,2111$; $df=1$). For 5 –24 employees the difference is significant ($p<0,0001$, $df=1$). For 25 employees or more the difference is also significant, but with a rather high p-value ($p=0,02$, $df=1$).

Figure 2: The year of establishment for construction and manufacturing firms in Zealand, Funen² and Jutland



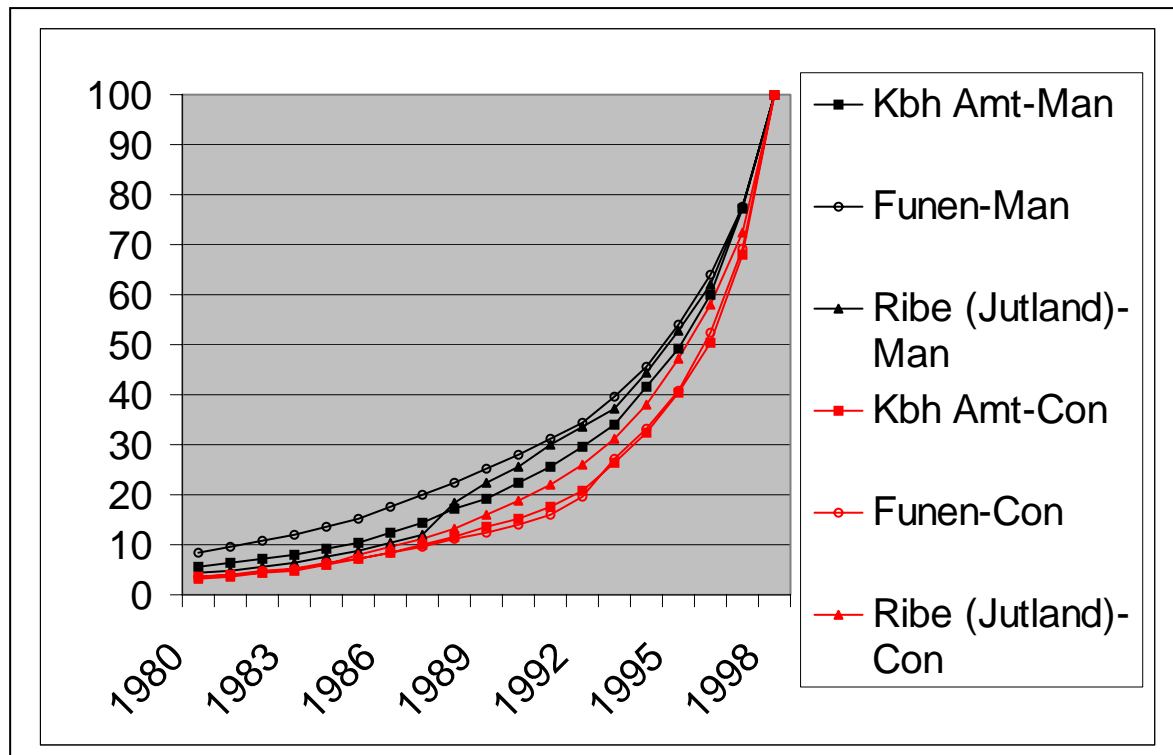
IDA-database. Own inquiries 2001.

The regional difference in year of establishment is not very profound in manufacturing (chi-square=53,49, df=36, p=0,031, and if the first year of registration, 1980, is excluded chi-square=52,3, df=34, p=0,023). However, the regional difference is strongly significant within construction (chi-square=152,36, df=36, p<0,0001, and if 1980 is excluded, chi-square=63,9, df=34, p=0,001).

The difference in year of establishment in manufacturing compared with construction is significant in all three regions (Zealand: chi-square=96,98, df=17, p<0,0001; Funen: chi-square=47,2, df=17, p<0,0001; Jutland: chi-square=150,96, df=36, p<0,0001).

² Bornholms and Storstrøms Amt is included in Funen.

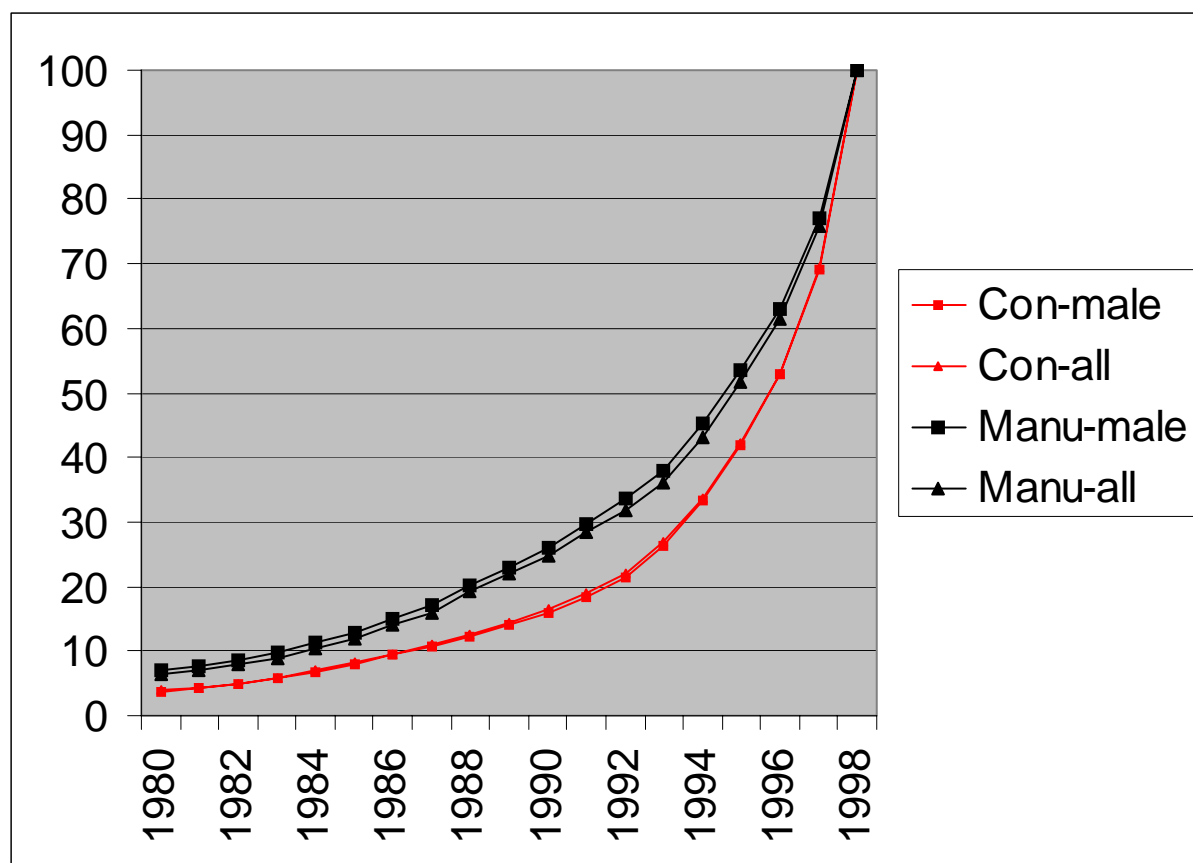
Figure 3: Year of employment for three counties at Zealand, Fun and Jutland³



IDA-database. Own inquiries 2001.

³ The three counties Københavns Amt, Fyns Amt and Ribe Amt were selected for further investigation as they with respect to year of establishment of firms had values close to the average of Zealand, Funen and Jutland respectively.

**Figure 4: Year of employment in construction and manufacturing firms
- all persons and males**



IDA-database. Own inquiries 2001.

Table 4: Educational background of employees and sector employment (%) - 1998

	General contractors	Bricklayers	Electricians	Plumbers	Carpenters	Painters
Public school or less	38	34	23	25	28	26
Highschool	3	2	3	2	3	2
Other basic vocational courses	21	10	16	31	9	9
Bricklayer	7	44	0	0	2	0
Carpenter	13	4	0	1	52	1
Plumber	1	0	1	31	0	0
Painter	1	0	0	0	0	59
Electrician	1	0	39	2	0	0
Supplementary Vocational Courses	3	1	12	6	2	1
Diploma	8	2	3	2	2	1
Bachelor	0	0	0	0	0	0
Master	2	0	0	0	0	0
Doctoral / Ph.D. degree	0	0	0	0	0	0
Not known	2	1	1	1	1	1
Total	100	100	100	100	100	100

IDA-database. Own inquiries 2001.

Dansk Resumé

Indledning

Byggeriets organisation har i stadig stigende grad været i fokus det seneste 10-år. Gennemgående for den danske såvel som udenlandske akademiske, erhvervsmæssige og politiske debat er ofte en antagelse om, at byggeriet for det første klarer sig dårligt (eksempelvis i forhold til produktivitet, innovation, læring, kvalitet, arbejdsmiljø med mere). For det andet, at problemerne – og dermed løsningerne – ikke primært er tekniske men snarere knytter sig til byggebranchens og –processens organisering. Populært kan man måske sige, at hvor meget af efterkrigstidens udviklingsindsats har set på relationen mellem bygningsdele, er relationen mellem mennesker nu i centrum.

Denne afhandling bidrager til denne diskussion. Ikke ved i udgangspunktet at kritisere eller komme med ændringsforslag. Men ved at prøve at forstå, hvad de økonomiske rationaler er ved byggeriets nuværende organisation – en organisation hvis delelementer kan genfindes i en lang række lande og som i en række sammenhænge forekommer at være meget stabile over tid og som derfor ikke uden videre kan afskrives som værende ineffektive.

Teori

Afhandlingens teoretiske ståsted *organisationsøkonomi*, altså den sammenlignende vurdering af omkostninger ved at producere og allokere ressourcer gennem forskellige ejerskabs- og koordinationsformer. Indenfor dette felt er særligt *informationsbaserede* tilgange til økonomisk organisation blevet vægtet, mens *incitamentsbaserede* tilgange, herunder transaktionsomkostningsøkonomi, har været tildelt mindre opmærksomhed.

Forskningsspørgsmål

Afhandlingen tager sit afsæt i tre empiriske forskningsspørgsmål

Forskningsspørgsmål A: Hvordan er arbejdsdelingen i byggeprocessen og hvad er konsekvenserne heraf for koordination?

Forskningsspørgsmål B: Hvilken rolle spiller virksomheder indenfor byggeriet i forhold til koordination: sker koordination i eller mellem virksomheder og hvilke grænser er der for at håndtere på hinanden følgende byggeaktiviteter indenfor en enkelt virksomhed?

Forskningsspørgsmål C: Hvilke koordinationsformer benyttes i byggeprocessen og hvordan håndterer de den information, der indgår i at koordinere byggeaktiviteterne?

De indbyrdes relaterede forskningsspørgsmål tager udgangspunkt i grundlæggende begreber indenfor organisationsøkonomien: arbejdsdeling og specialisering (forskningsspørgsmål A), koordination og koordinationsformer (forskningsspørgsmål C) samt organiseringen af koordination, herunder betydningen af virksomheder (forskningsspørgsmål B).

Empiri

Til belysning af forskningsspørgsmålene er gennemført et case studie af koordinationsformer i opførelsen af et tag på et fleretages boligbyggeri beliggende i København. Dette dybdegående casestudie er blevet suppleret med en mere summarisk case af koordinationsformer anvendt ved møbelproduktion, der har en række fællestræk med tagproduktion, men som adskiller sig ved en højere grad af gentagelse.

Statistikke kilder har været brugt til at dokumentere graden af udsving i den samlede efterspørgsel i byggebranchen i sammenligning med andre brancher. Endvidere er særkørsler i en unik dansk database – IDA-databasen – blevet benyttet til at undersøge afledte ændringer i relationen mellem henholdsvis virksomheder og personer. IDA-databasen giver også en række indikationer på de i forskningsspørgsmålene rejste problemstillinger (problemstillinger der som bekendt er behandlet mere detaljeret i casestudiet).

Konklusion

Med udgangspunkt i disse kilder konkluderes følgende i forhold til de tre forskningsspørgsmål.

Byggeprocessen er kendetegnet ved en lav grad af gentagelse på makro-niveau (forårsaget af ændringer i den samlede efterspørgsel) der yderligere forstærkes ved forskelle i det enkelte byggeprojekt. Dette

medfører en høj grad af foranderlighed i byggeprocessen eftersom at virksomheder, personer og de indbyrdes afhængigheder mellem aktiviteter varierer fra et byggeprojekt til et andet til trods for, at det færdige produkt – og i særdeleshed dets enkelte dele – ikke nødvendigvis er væsensforskelligt og til trods for, at den anvendte teknologi og arbejdsmetoder fremstår som meget stabil. Den kombinerede effekt af mangel på gentagelse på makro- og mikroniveau er en nøgle til at forstå arbejdsdelingen, organiseringen af koordination og de anvendte koordinationsformer anvendt i byggeprocessen (de tre forskningsspørgsmål).

Generelt betyder hyppigheden og størrelsen i udsving i efterspørgsel, at fordelene ved at specialisere sig i mindre grad opvejer de heraf følgende ulemper i form af mindre tilpasningsevne. I denne situation er der fordele ved at benytte en begrænset og ikke virksomhedsspecifik arbejdsdeling (svarende til de forskellige fag). Denne fordel knytter sig til forskellige niveauer: sektoren, virksomheden, det enkelte byggeprojekt og det enkelte individ.

Foruden at afbalancere fordelene ved specialisering versus tilpasningsevne, så mindsker opdelingen i fag – det vil sige faglært og højtuddannet arbejdsarbejdskraft samlet i homogene grupper på person og virksomhedsniveau – også de til koordinationsprocessen knyttede informationsomkostninger. For det første muliggør fagene fælles gentagelseeffekter, herunder fælles forventninger, mellem personer og virksomheder, der ikke har forhåndskendskab til hinanden (og som heller ikke har udsigt til at skulle gentage samarbejdet). For det andet bevirker brugen af faglært arbejdsarbejdskraft, at aktiviteter der ikke er helt identiske fra gang til gang i et vist omfang kan håndteres decentralt. Standardisering af in- og outputs såvel som af arbejdsprocesser erstattes således af standardisering af kompetencer.

Hvad angår forskningsspørgsmål B så bevirker behovet for at kunne tilpasse sig til nye situationer, at udførende byggevirkomheder (fagentreprenører eller underentreprenører) i meget begrænset omfang håndterer sekvenser af på hinanden følgende aktiviteter. I stedet udfører de aktiviteter "her og der" i værdikæden på det enkelte byggeprojekt såvel som deltager i mange forskellige byggeprojekter samtidigt. Byggevirkomhederne rolle som koordinatore er således altovervejende begrænset til koordination *på tværs* af værdikæder. Koordination *indenfor*

den enkelte værdikæde varetages hovedsageligt af virksomheder specialiseret heri, nærmere bestemt af rådgiverne (arkitekt og rådgivende ingeniør, der især er aktive i planlægningsfasen) og af byggeledelsen (typisk en hoved- eller totalentreprenør, der især er involveret i udførelsesfasen). Specialisterne i koordination og specialisterne i produktion er dermed placeret i separate virksomheder. Denne brug af tredjeparts koordinering løser en række af de informationsproblemer (samt incitamentsproblemer) der er knyttet til mange forskellige aktører der opererer "her og der" i værdikæden. Men adskillelsen af produktion og koordination indebærer også en række problemer hvad angår afbalanceringen af koordinations- og produktionsomkostninger og hertil knyttede forbedringer og innovation.

Hvad angår forskningsspørgsmål C, peger empirien i retning af, at flere forskellige koordinationsformer anvendes samtidigt for at koordinere de enkelte aktiviteter i byggeforløbet. På håndværksniveauet er det gennemgående billede at information om *hvem* der skal udføre hvilke aktiviteter og *hvornår* de skal udføres tilvejebringes gennem overordnede personer placeret i det samme firma som håndværkeren. Information om *hvilke materialer* der skal bruges og *hvor meget* og præcis *hvad der skal laves* er derimod bestemt af instrukser fra eksterne rådgivere. Endelig er håndværkernes erfaring og rutiner oftest afgørende hvad angår information om *hvilke redskaber* og *hvilke fremgangsmåder* der skal benyttes.

Denne observation synes på den ene side at være i overensstemmelse med den teoretiske forventning om, at det er svært at håndtere komplekse, ikke-gentagne aktiviteter med mange aktører involveret ved hjælp af en enkelt koordinationsform. Omvendt blev det i empirien konstateret, at de anvendte koordinationsformer i mindre omfang end teoretisk forventet modsvarer forskelle i de indbyrdes afhængigheder mellem aktiviteter. En mulig forklaring på disse "robuste" kombinationer af koordinationsformer er, at selv om de ikke minimerer omkostningerne ved at *bruge* forskellige koordinationsomkostningerne, så er de ikke desto mindre hensigtsmæssige når omkostningerne ved at lære hvilken koordinationsform der passer til et givent sæt af aktiviteter - samt omkostninger ved at indføre denne koordinationsform - medtænkes. Endvidere nuancerer empirien den i litteraturen ofte antagede sammenhæng, at koordinationsformer er bestemt af (den

indbyrdes afhængighed i) aktiviteterne. Som observeret i møbelproduktion, kan det omvendte også være tilfældet, altså at aktiviteter defineres på en sådan måde, at de kan håndteres med bestemte koordinationsformer.

Teoretiske perspektiver

Overordnet set bidrager afhandlingen til en teoridannelse om hvorledes koordination organiseres og finder sted – især i situationer kendetegnet ved foranderlighed.

Eksterne forandringer med deraf følgende mulighed for forandring i den enkelte aktivitet medfører *ikke* fraværet af en arbejdsdeling. Men den medfører derimod en bestemt og begrænset arbejdsdeling knyttet til grupper af virksomheder og personer der i forhold til hinanden er specialiseret, men som internt er homogene. Fordele herved er samtidig specialisering og tilpasningsevne. Blandt ulemperne er koordinationsomkostninger ved innovation som følge af systemiske innovationer.

Den enkelte virksomhed spiller en *begrænset* rolle som koordinator. Modsat hvad det må forventes at gælde for aktiviteter underlagt mindre grad af eksterne forandringer, så udfører nogle virksomheder kun koordination på tværs af værdikæder, mens andre virksomheder primært udfører forandringer i den enkelte værdikæde. Med andre ord så synes koordination direkte mellem to virksomheder og i særdeleshed koordination ved en tredje part at være afgørende ved lav grad af gentagelse i eksterne forhold.

Underliggende for denne diskussion er en forståelse af virksomheden som én måde at reducere informationsomkostninger på. Teoretisk og empirisk supplerer afhandlingen derved overvejende incitamentsbaserede teoridannelser til at forstå virksomheders eksistens, grænser og interne organisering.

Adam Smith fremhævede *gentagelse af aktiviteter* som årsagen til arbejdsdelingen og deraf følgende lavere *produktionsomkostninger*. Denne afhandling har fundet at *gentagelse af sekvenser af aktiviteter* som en anden potentiel kilde til vækst, da gentagelse heraf mindsker *koordinationsomkostninger*.

Afhandlingen udvider på en række punkter forståelsen af den hensigtsmæssige brug af koordinationsformer. Ved at supplere omkostninger ved at *bruge* koordinationsformer med omkostninger ved

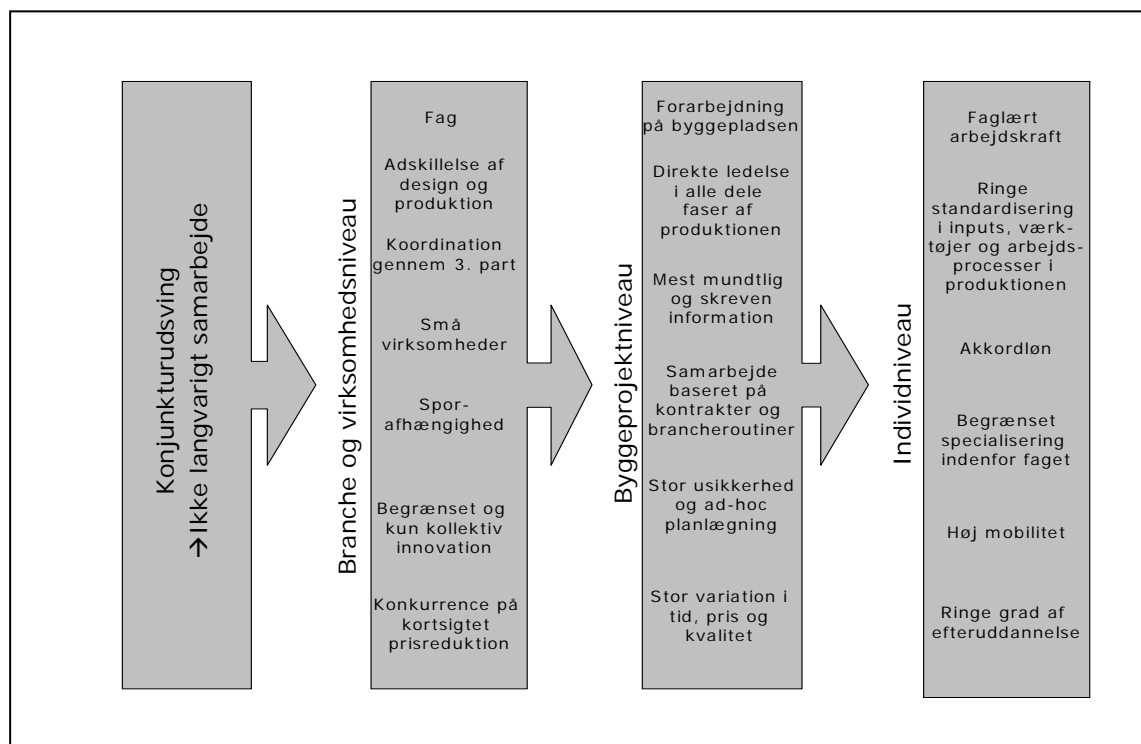
at *lære* om koordinationsformer gøres det klart, at koordinationsformer – især ikke ved lav grad af gentagelse i sekvenser af aktiviteter – ikke kan forventes nøje af afspejle de koordinerede aktiviteter. De informationsrelaterede egenskaber ved aktiviteter kan således godt være forskellige uden at koordinationsformerne nødvendigvis er det. Men forholdet mellem aktiviteter og koordinationsformer er ikke blot mindre klart end især angivet i kontingensteorien. Kausaliteten kan decideret være omvendt. Hvor kontingensteori tog udgangspunkt i at egenskaberne ved aktiviteterne var givne og at samklang mellem aktiviteter og koordinationsformer alene kunne ske ved at vælge de rigtige koordinationsformer, har afhandlingen påvist at udformningen af aktiviteter og deres indbyrdes bindinger også er en ledelsespåvirkelig variabel.

Graden af gentagelse i eksterne forhold synes alt i alt at have en afgørende indvirkning på hvordan koordination organiseres og udføres. I det omfang denne konklusion er general gyldig, peger den i retning af at aktiviteter, personer og virksomheder og måske endda brancher der som følge af et højt niveau af eksterne ændringer – ikke bare i samlet efterspørgsel, men måske også af andre årsager som eksempelvis skift i kundernes smag eller i den anvendte teknologi – vil have en række fællestræk, der dårlig kan indfanges ved teoridannelser udviklet i relation til gentagne produktion.

Empiriske perspektiver

Afhandlingen påpeger at byggeriets organisation og væremåde i mange henseender er en fornuftig måde at håndtere konjunkturudsvingenes krav om fleksibilitet. Og at byggeriets nuværende organisation på en række forskellige niveauer kan ses som et logisk svar på behovet for fleksibilitet (figur 1) .

Figur 1: Konsekvenser af kortvarigt samarbejde (byggeriets nuværende organisering)



Samtidig påvises en række indbyggede problemstillinger i byggeriets nuværende organisering. Ikke mindst, at det grundlæggende behov for at være ens er hæmmende for virksomheders og individers interesse i at innovere og dygtiggøre sig. Dette gør det igen tvivlsomt om byggeriets nuværende organisering på langt sigt er den mest hensigtsmæssige.

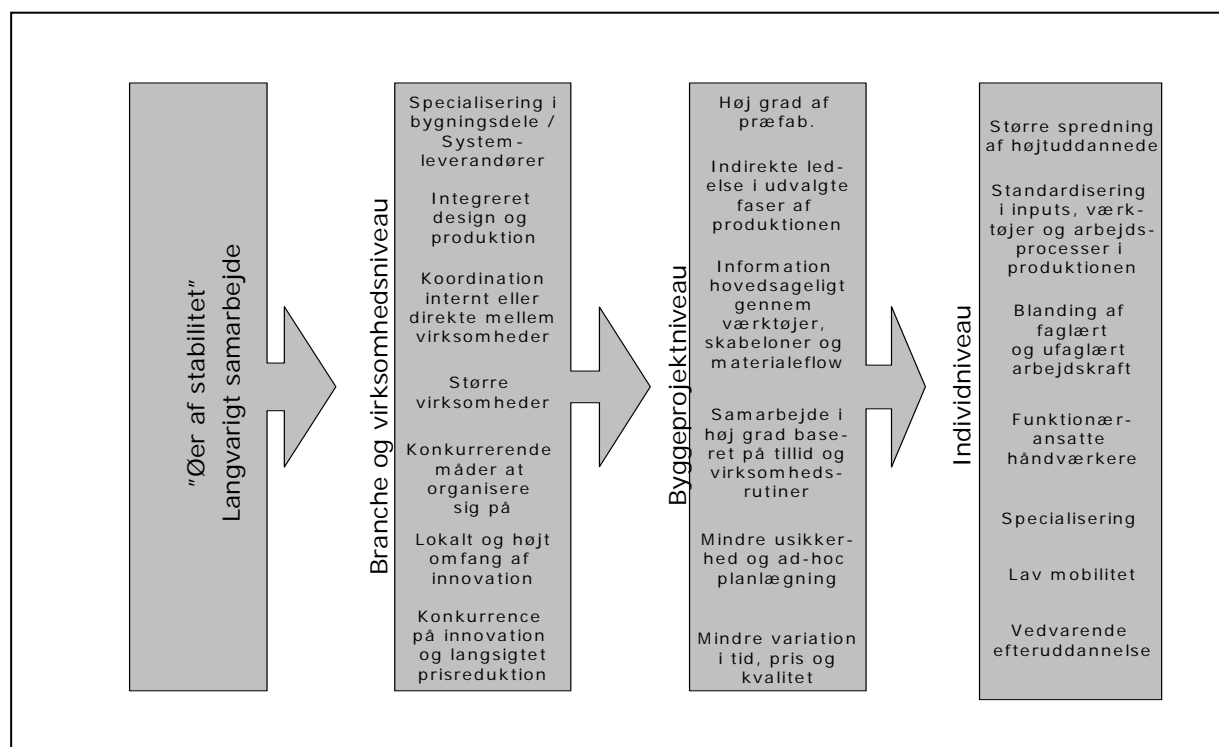
Med udgangspunkt i ovenstående analyse, bør en række af de forhold der ofte fremhæves som typiske for byggeriet – adskillelse af design og produktion, kortsigtet priskonkurrence, lille brug af præfabrikation, manglende tillid, begrænset efteruddannelse og så videre – ikke ses som selvstændige problemer, men som konsekvenser af en mere grundlæggende problemstilling, nemlig behovet for at tilpasse sig især markedsudsvingene.

Af samme grund er det også mod behovet for markedstilpasninger at opmærksomheden rettes i afhandlingens afsluttende diskussion af muligheder for at forny sektoren. Konjunkturer er svære at undgå - i hvert fald så længe at bygninger holder længe og koster mange penge. Mest realistisk er det nok at forestille sig "øer af stabilitet". Enten tilvejebragt gennem "klumpning" af offentligt eller privat udbud. Eller

ved at nogle af branchens større aktører er i stand til i sig selv at absorbere udsvingene lokalt. Selv i perioder med en lille byggeaktivitet vil der eksempelvis altid være nogen byggeaktivitet i et større entreprenørfirma. Man kunne således forestille sig en todelt struktur, hvor en del af virksomheden er specialiseret i at optimere en jævn strøm af byggeopgaver i langvarige samarbejdsrelationer (måske især opgaver tilvejebragt ved projektudvikling eller i totalentreprise, hvor entreprenøren selv sætter holdet), mens den anden del af virksomheden (som i dag) er specialiseret i at håndtere variationen i stadig skiftende samarbejdsrelationer.

"Øerne af stabilitet" vil på sigt muliggøre en ganske anden måde at organisere byggeprocessen på. Med figur 1 som afsæt, kan måske anes hvilke muligheder "øer af stabilitet" med dertil hørende langvarigt samarbejde vil afstedkomme (figur 2).

Figur 2: Mulige konsekvenser af langvarigt samarbejde (byggeriets fremtidige organisering?)



Hvis bare en smule af dette er rigtigt, indebærer det to ting. For det første, at der er store muligheder for at forandre og formentlig forbedre sektoren. For det andet at den (eller i hvert fald en del af den) vil se helt

anderledes end den byggesektorer, som vi igennem århundrede har
vænnet os til.

